THE RUSSIAN S-300 AND S-400 MISSILE SYSTEMS

STEVEN J. ZALOGA

ILLUSTRATED BY FELIPE RODRÍGUEZ

NEW VANGUARD 315

THE RUSSIAN S-300 AND S-400 MISSILE SYSTEMS

STEVEN J. ZALOGA ILLUSTRATED BY FELIPE RODRÍGUEZ

CONTENTS

INTRODUCTION 4

ORIGINS 4

DEVELOPMENT 9

- S-300P Biryuza (SA-10A Grumble)
- S-300PS Volkhov M6
- S-50 Moscow Defense Ring
- The Second Generation: S-300PM Volkhov M-6M (SA-20A Gargoyle)
- S-300PMU Export System
- Catering to the Export Market: S-300PMU-2 Favorit (SA-20B Gargoyle)
- S-350 Vityaz (SA-28)
- The Third Generation: S-400 Triumf (SA-21A Growler)
- The Naval S-300F Fort/Rif (SA-N-6 Grumble)
- S-300V (SA-12 Giant/Gladiator)
- S-300VM (SA-23)
- S-500 Prometey ATBM

ASSESSMENT 46

FURTHER READING 47

INDEX 48

THE RUSSIAN S-300 AND S-400 MISSILE SYSTEMS

INTRODUCTION

The S-300 missile system is one of the world's most sophisticated and effective air defense weapons. It forms the backbone of the Russian national air defense network as well as those of the former Soviet republics. The S-300 has been widely exported and is the principal strategic air defense system of China, Iran, Vietnam, Syria, and several other countries. Over the years, new generations of the system have appeared, including the S-350, S-400, and S-500. The S-300 appears regularly in the news for its role in various conflicts and in international confrontations.

ORIGINS

In the aftermath of World War II, the Soviet Union had an independent branch of the armed forces for national air defense, called the PVO-Strany. Until the mid-1950s, its principal weapons consisted of antiaircraft guns and interceptor aircraft. The first Soviet air defense missile system was the S-25 Berkut (SA-1 Guild). Its deployment was limited to the Moscow area starting in 1954.

The complexity, cost, and technical shortcomings of the S-25 Berkut prompted the PVO-Strany to sponsor a more cost-effective air defense system that could be deployed on a national basis. This led to the S-75 (SA-2 Guideline). Design of the S-75 system was cooperatively undertaken by two design bureaus that would form the core of Soviet strategic surface-to-air missile (SAM) development to this day. The KB-1 (later Almaz) bureau under chief designer Aleksandr Raspletin had overall responsibility for the program. The new missile was developed by the OKB-2 (later Fakel) design bureau under Pëtr Grushin. Deployment of the S-75 system began in 1958 and it became the most widely deployed SAM of its generation with about 4,800 launchers in service by 1969. It was also credited with being the first SAM to shoot down a hostile aircraft when an S-75 in China shot down a Taiwanese RB-57D reconnaissance aircraft on October 7, 1959. The S-75 became internationally famous on May 1, 1960 when a CIA U-2 reconnaissance aircraft piloted by Francis Gary Powers was shot down near Sverdlovsk. The S-75 was widely exported and saw extensive combat during the Vietnam War. It later saw combat in many other conflicts, especially in the Middle-East wars of 1970 and 1973.

The S-200 (SA-5 Gammon) was one of the most powerful SAMs developed for the PVO-Strany. Although well suited to dealing with high-altitude, supersonic bombers, by the time it arrived the threat had shifted to low-flying cruise missiles.

The S-75 had been deployed to deal with high-altitude strategic bombers such as the USAF B-52 Stratofortress at medium to high altitudes. The effectiveness of the S-75 led the US Strategic Air Command to develop new tactics to avoid the SAM threat, including the use of nap-of-the-earth tactics to exploit the shortcomings of the S-75 at low altitudes. This was anticipated by PVO-Strany and, in May 1957, the S-125 (SA-3 Goa) program began to supplement the S-75 at low altitudes. Deployment started in 1964 and about 1,400 launchers (4,600 launch rails) were in Soviet service by 1981. Like the S-75, the S-125 was widely exported. It first saw extensive combat in 1970 in the War of Attrition between Egypt and Israel.

Further development of the PVO-Strany air defense network was heavily shaped by anticipated strategic bomber threats from the United States, Britain, and France. The US development of the high-altitude, supersonic B-58 Hustler and XB-70 Valkyrie in the early 1960s as well as the SR-71 Blackbird strategic reconnaissance aircraft led to a PVO-Strany requirement for a new SAM system optimized for the long-range, high-altitude mission. This began in 1958 as the S-200 Angara (SA-5 Gammon). By the time that the S-200 entered service in 1967, the XB-70 program had been canceled and the B-58 Hustler was retired in 1970. In spite of the evaporation of the high-altitude threat, the S-200 continued to be deployed, though on a reduced scale compared to the S-75/S-125 with about 2,030 launchers in service by 1985. The S-200 was exported on a much more limited scale than its predecessors due to its sophistication and cost.

Soviet strategic SAM procurement 1957–66*

	1957	1958	1959	1960	1961	1962	1963		1966
S-25	1,218	1,400	1,130	600	65	900	800		850
S-75	578	1,200	4,754	7,581	8,404	6,900	7,900		1,000
S-125				100	425	1,200	1,500		500
S-200							30		400
SAM Batteries	30	130	182	205	250	255	235		70

**Source:* "Armament Deliveries to the Soviet Ministry of Defense 1957–1966," GOSPLAN

After a frantic program to deploy a nationwide SAM network from the mid-1950s to the mid-1960s, the PVO-Strany began to take a look at future requirements based on the rapidly changing strategic balance with the United States. While strategic bombers had been the main threat in the 1950s, by the 1960s strategic ballistic missiles including both intercontinental ballistic missiles and submarine-launched ballistic missiles were fast becoming the predominant threat. Even though bombers remained a significant aspect of the US strategic arsenal, the technological and tactical features of this threat changed by the late 1960s. Since high-altitude attacks had been deterred by the Soviet SAM network, low-altitude attack profiles dominated US Strategic Air

Command tactics. This was also reflected in new bomber-launched missiles. The first of these was the AGM-28 Hound Dog cruise missile that entered service in 1960. It was designed to attack Soviet SAM sites or to permit the B-52 to attack from stand-off ranges outside the SAM network. Another penetration aid was the ADM-20 Quail decoy. This small missile could be launched ahead of the B-52 to confuse Soviet air defenses and to soak up Soviet SAMs that might otherwise be used against the parent bomber. B-52 bombers typically carried two of these when they were introduced in 1961.

The Hound Dog's flight characteristics made it vulnerable to the S-125. The Hound Dog was the size of a fighter plane so only two could be carried on a B-52. It was followed in 1971 by the AGM-69 SRAM (short-range attack missile). This was a small, nuclear-armed, aero-ballistic missile specifically designed to burn corridors through the Soviet SAM network with low-yield nuclear warheads. A B-52 could carry up to 20 SRAMs, or a mixture of SRAMs and nuclear free-fall bombs.

The Hound Dog was ultimately replaced in 1982 by the much smaller AGM-86B ALCM (air-launched cruise missile) with the B-52 capable of carrying 12–20 missiles each. This became the principal weapon of the B-52 and remains in service to this day. Beyond the air-launched threats, the US began deploying the Tomahawk cruise missile both in a ground-launched configuration in 1983 and a ship/submarine-launched configuration in 1984. The Tomahawk flew a nap-of-the-earth trajectory, exploiting the vulnerabilities of PVO-Strany SAMs at low altitude. Besides these cruise missiles, new American strategic bombers were on the horizon in the late 1960s and early 1970s including the FB-111 and B-1A bombers, optimized for low-altitude attack.

The latest Soviet SAM, the S-200 Angara, was not well configured to deal with the low-altitude challenge. In addition, Soviet missile and radar technology had advanced considerably since the mid-1950s when the S-25, S-75, and S-125 were developed. In 1966, the chief of the PVO-Strany, Marshal P. F. Batitskiy, headed a delegation to North Vietnam to examine the performance of S-75 missile battalions that had been in combat against American aircraft since the summer of 1965. The delegation discovered that the S-75 was becoming increasingly ineffective as the US forces improved their electronic warfare capabilities.

U.S. AIR FORCE

The advent of small, low-flying cruise missiles such as the US Strategic Air Command's AGM-86 ALCM forced the PVO-Strany to rethink its requirements for strategic air defense. This strongly influenced the S-300P requirement. (US DoD)

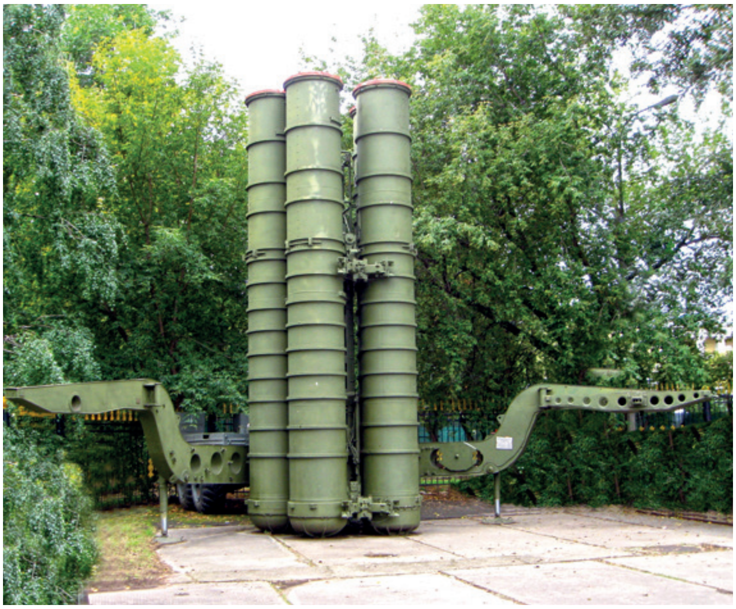
Soviet designers of simple weapons such as the AK-47's Mikhail Kalashnikov achieved worldwide fame. But the designers of the Soviet Union's most powerful and sophisticated weapons remained unknown due to secrecy. These are two of the key designers behind the strategic air defense systems, Boris V. Bunkin of Almaz on the left and Pëtr D. Grushin of Fakel on the right.

Based on the initial Vietnam experiences, an industry study identified five primary shortcomings of the S-75 and S-125 systems. Both systems relied on a single-channel fire control radar system that made them especially susceptible to electronic countermeasures (ECM). A missile battalion's engagement radar could engage only one target at a time. During high-intensity combat, the launcher battalions quickly expended their missiles but reloading was extremely time consuming. The existing systems had shortcomings in terms of coverage and had significant dead-zones where their sensors could not see or guide the missiles. In the face of hostile air-to-surface missiles, the battalions were essentially static and required too much time to be relocated and put back into action; greater mobility was needed.

PVO-Strany wanted a new medium-range system capable of dealing with a wide range of threats including low-flying strike aircraft and various types of air-launched missiles. They also sought a new generation system with reduced costs, higher reliability, easier operation, and fewer personnel. There was considerable hope that such a system was feasible in view of the shift from tube (valve) electronics to semi-conductors, the shift from analog mechanical computers to digital electronic computers, and the possibility that phased-array radars could replace traditional mechanically steered radars.

The Almaz design bureau was at the forefront of microelectronics development in the USSR, and the chief of its electronics division, Fëdor V. Lukin, went on to become the first director of the new Center for Microelectronics in Zelenograd in February 1962. This institute spearheaded the new Soviet microelectronics industry. The new air defense system would become one of the primary catalysts for the development of the Soviet microelectronics and computer industry, since commercial applications had little priority in the Soviet Union.

The primary advocate for the new air defense system was Aleksandr Raspletin who headed the Almaz design bureau. Raspletin argued that the new system should not only replace much of the PVO-Strany arsenal, but serve as a unified system to satisfy the requirements of the other services. It was initially called S-500U, the U indicating "Unified" (*unifitsirovanniy*). Besides the PVO-Strany, the army had its own air defense branch, the PVO-SV (*Sukhoputnie Voiska*: ground forces) and the navy had its own administration for developing shipboard air defense systems. In late 1966, a commission was formed, headed by Raspletin and including representatives from both the industry and military branches with an aim to establish basic guidelines for the new system. This emerged in December 1966 as a draft for a formal authorization by the Central Committee and Council of Ministers. This was an essential first step in the program in view of the extremely high cost of such a system as well as the commitment of a very large portion of the Soviet Union's limited electronics industry to the new effort.



The original S-300P system used the 5P851 launcher system. This was a semi-mobile configuration, taking over an hour to prepare after moving it into position.

Although the draft to start the S-500U was approved, resistance to the program developed in 1968 from rival design bureaus, especially Veniamin P. Yefremov, the chief designer of NIEMI (Electromechnical Research Development Institute), subsequently known as Antey. Yefremov had headed the development of the PVO-SV missile systems including the Krug (SA-4 Ganef). Yefremov was supported by General Pavel N. Kuleshov, the head of the GRAU (Main Missile-Artillery Directorate) that supervised Soviet missile development programs. Yefremov rightly realized that a unified SAM system would probably push his design bureau out of the effort and concentrate it under Raspletin's rival Almaz bureau. He won army support for his opposition, arguing that a unified system would be dominated by the PVO-Strany requirements. The army wanted a fundamentally different system than the type envisioned by the PVO-Strany. In particular, it wanted an anti-ballistic missile system capable of defeating the growing array of NATO tactical ballistic missiles. The S-500U plan was focused on strategic aircraft and cruise missiles rather than ballistic missiles, requiring very different system characteristics.

This controversy came at an awkward moment within the missile industry. Raspletin, 59 years old, died of a stroke on March 8, 1967. Leadership of the Almaz design bureau was such an important post that it required approval from the upper leadership of the Kremlin. Several candidates were vying for the post, and the issue was not settled until a year later on March 7, 1968 when Boris Bunkin was selected. The controversy over the fate of the S-500U lasted well over a year during this interregnum. As some observers later observed, the opposition to S-500U would have been firmly rejected if Raspletin was still alive because he had considerable influence in the Kremlin, especially with the head of Soviet military procurement, Dmitri Ustinov. The S-500U plan perished with Raspletin.

By early 1969, a compromise had been reached favoring consensus over controversy, a hallmark of the Brezhnev years. The S-500U plan was replaced by the S-300 program. The S-300 program was in fact three separate programs. The PVO-Strany effort was called S-300P, the "P" referring to the PVO-Strany. The army program was called S-300V, the "V" indicating Voiska (army). The naval program was called S-300F, the "F" indicating Flot (fleet). Bunkin's Almaz bureau was assigned to head S-300P; Yefremov's Antey led the S-300V program and the Altair bureau under V. A. Bukatov headed the naval S-300F program. The hope was to use common subsystems between the three different programs but this would be frustrated by bureaucratic rivalries.

DEVELOPMENT

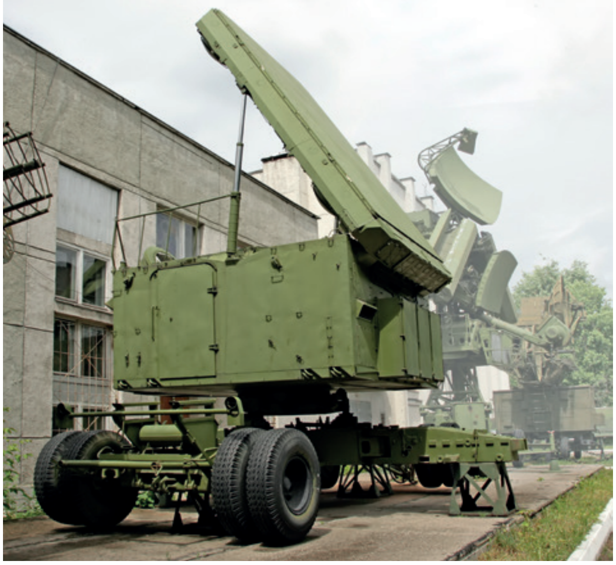
S-300P Biryuza (SA-10A Grumble)

The S-300P program was one of the largest and most expensive Soviet weapons programs of the Brezhnev years. It involved 20 large institutions and more than 150 smaller bureaus and factories. Early work focused on important advances in basic technologies, particularly on new microprocessors, new radar assemblies, and new digital computers. With Almaz as the overall design bureau for the program, other key design efforts were undertaken by Fakel (missiles), the Novosibirsk Research Institute for Measurement Devices (surveillance radar), Nizhniy Novgorod Industrial Plant (launch and reload systems), Minsk Automotive Plant (wheeled vehicles), and the Voronezh Communications Research Institute (communications network).

Previous Soviet strategic SAMs had relied on a booster to launch the missile. This created a problem early in the engagement since the missile could not be guided until the booster dropped away and the main sustainer engine ignited. This created a dead-zone for several kilometers near the launcher. Another problem was that the older generation of missiles was left exposed on the launcher, subject to the harsh Russian weather. Many of them used storable liquid propellant for the sustainer engine that limited their shelf life and increased maintenance requirements. Fakel's solution for the new V-500 series of missiles was to use a single-stage, solid-fuel missile fired from a TPK (*transportniy puskovoy konteiner*: transport-launcher container). The advantage of the container and solid-fuel missile was that the missile remained hermetically sealed until launch, and the solid-fuel propulsion minimized the need for periodic maintenance. The original V-500 missiles used mid-body fins somewhat like the US Navy Tartar and the Soviet Buk (SA-11) missile. The first unguided test launch occurred on March 4, 1970. This fin configuration increased the diameter of the TPK and was eventually reconfigured as a set of rear fins that could be folded until launch.

Missile ejection from the container proved troublesome. The initial configuration used a booster charge at the rear of the missile. This risked rupturing the rear of the TPK and was also unsuitable for naval use since it was planned to launch the missile from below deck. A more exotic scheme was developed to eject the missile using an electro-magnetic catapult but this proved too expensive and cumbersome. Finally, the use of gas generator was selected, based on similar work for Soviet strategic ballistic missiles. The gas generator was not as energetic as a rocket booster, and ejected the missile about 20 meters above the TPK where the main solid-fuel rocket motor ignited.

The guidance approach favored by Fakel was a track-via-missile (TVM) terminal homing system. The antenna on the missile picked up reflections from the engagement radar and fed the data back to radar to adjust the final approach to the target.



The original S-300P system used towed 5N63 (Flap Lid A) radars like this example displayed at the Moscow District PVO Museum at Zarya, near Moscow.

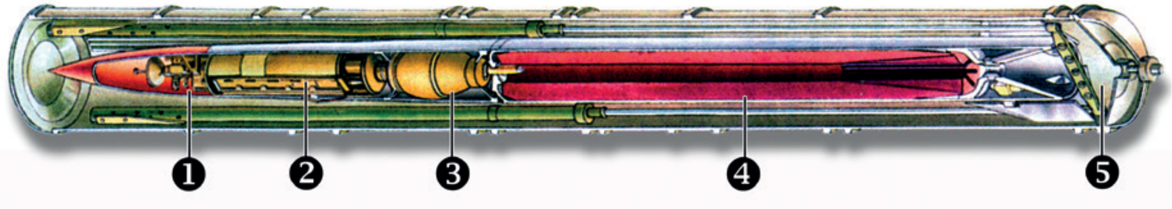
This increased missile accuracy and at the same time permitted increased range. The development of this guidance method proved to be protracted so Fakel proposed a two-stage effort. The initial V-500K (K: *kommandniy*: command) missile used a much simpler command guidance. The missile began its intercept course shortly after launch based on initial targeting information fed into its flight control system prior to launch and relying on its inertial guidance platform. The missile and target were tracked by the engagement radar, and the radar sent mid-course guidance corrections and eventually the terminal guidance instructions. The V-500K missile promised to be much quicker to develop and also less expensive to manufacture than the preferred TVM missile. This missile became better known by its GRAU designation, 5V55K, rather than its internal Fakel designation of V-500K.

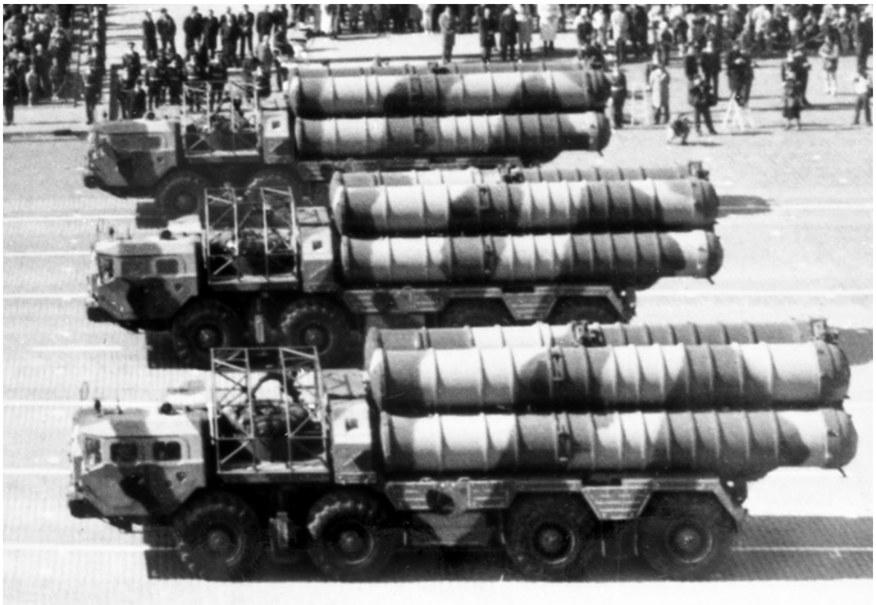
The first launch of the baseline V-500K missile took place on December 10, 1975. Three months later, the first attempt was made to intercept a simulated air target but it wasn't until June 30, 1976 that a MiG-19M drone target was shot down by a 5V55K missile. Tests of an integrated S-300P system with the 5V55K missile began on December 27, 1977 and lasted until March 31, 1979. During these state trails, 275 missile launches were conducted, and 104 targets were hit; many engagements involved two missiles against a single target drone. The system was formally accepted later in 1979. Serial production of the V-500K missile began in June 1980 at the Avangard Plant near Moscow, the Severniy Plant in Leningrad, and subsequently at the Zhulyanskiy Vizar Plant near Kiev.

Development of the V-500R with the TVM guidance system took about three years longer than the command-guided version. The 5V55R missile was first tested on April 25, 1978 and it was formally adopted for service by government decrees on October 30, 1981 as the 5V55R. Although more expensive than the V-500K, the V-500R/5V55R extended the effective range of the missile out to 75km and the system was much less vulnerable to electronic countermeasures than the earlier missile. Besides the basic versions of the missile with a high-explosive warhead, the nuclear-armed V-500S (5V55V) was available for some selected units. Another variant was the 5V55PM which had a radiation-homing seeker with home-on-jam features to attack electronic warfare aircraft or bombers fitted with electronic jammers.

The S-300P system was designed from the outset to be more mobile than previous strategic SAM systems. Launcher development was undertaken by the KBSM (Special Industrial Design Bureau) in Leningrad. The MAZ-543M heavy truck was selected as the basis for the system because it had already proved successful with other missiles such as the 9K72 Elbrus (SS-1b Scud) and 9K76 Temp (SS-12 Scaleboard) ballistic missile launchers. Early developmental work concluded that development of a mobile version of S-300P would prove to be both time-consuming and expensive.

This is a cross-section of a 5V55R missile in its 5P86 TPK transport-launch canister. The basic missile subcomponents are the guidance antenna (1); flight control system (2); warhead (3); solid rocket motor (4) and gas generator (5).





The public debut of the S-300PS was at the May 9, 1990 Victory Day parade in Moscow. These are three of the 5P85D TELs that took part.

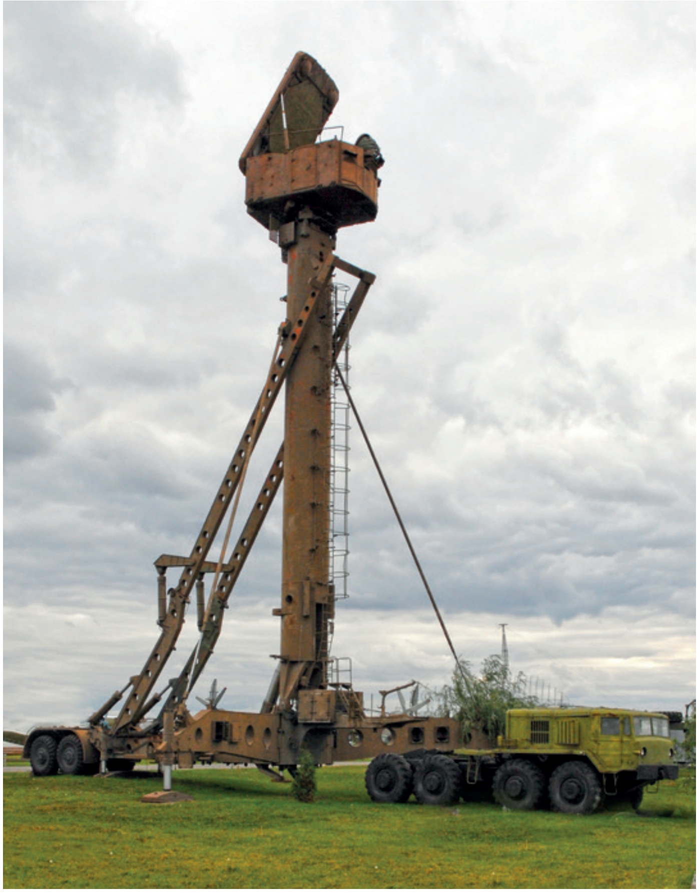
As a stopgap, other alternatives were considered. The 5P85.1 was a semi-mobile launcher consisting of a transporter-erector trailer, towed to the launch site using a KrAZ-260V tractor truck. The 5P85.2 was a silo-based launcher containing multiple launch tubes in a silo. The silos happened to be similar in size to those used by Soviet strategic ballistic missiles. Since the Soviet Union was beginning to engage the United States in strategic arms limitation talks, the widespread deployment of S-300P silos around the country could be misconstrued as ballistic missile silos. This could gravely complicate the arms control talks so this alternative was abandoned.

Codenamed Biryuza (*Turquoise*), the semi-mobile version of the system was designated as S-300PT (T: *transportiruyemiy*; transportable). It was eventually dubbed SA-10A Grumble in the West. The first 5P85.1 semi-mobile launchers were tested in 1973. The original conception was to deliver the missiles pre-loaded in a magazine with five missile launch cells. This configuration was quickly abandoned since a malfunction in any of the five cells prevented the use of the other missiles. Instead, the missiles were delivered in individual TPK containers. The definitive version of the 5P85.1 could carry four TPKs. The 5P85.1 was subsequently designated as the 5P851 when it entered production at the Gorkiy plant in Novoye Sormovo in August 1977.

The S-300P pioneered the use of phased-array radars in an air defense system. Previous systems had relied on the traditional mechanically scanned radar. These can be compared to a giant searchlight that rotates to illuminate potential targets with a broad beam of continuous radio signals. In contrast, a phased-array radar contains hundreds of discrete individual emitters that are electronically steered. Rather than a single continuous radio beam, the phased-array emits multiple, intermittent, pencil beams narrowly aimed at multiple objects. Typically, the beams are used simultaneously to track the target, track the missile, search for other possible targets, and send commands to multiple missiles to intercept multiple targets.

The basic engagement radar for the S-300PT system was the phased-array 5N63 (Flap Lid). It was analogous to the AN/MPQ-53 radar of the

US Army's Patriot system. A major difference was that the 5N63 was primarily intended for fire control while the MPQ-53 also had broader surveillance capabilities. The 5N63 radar could engage up to six targets simultaneously using 12 missiles.



The deployment of the S-300P in the forested areas around the Moscow ring road led to the development of the massive Novokramatorsk 40V6M masts that permitted the system radars to avoid terrain obstructions. This is an example with the 5N63 (Flap Lid A) engagement radar. (Jim Kinnear)

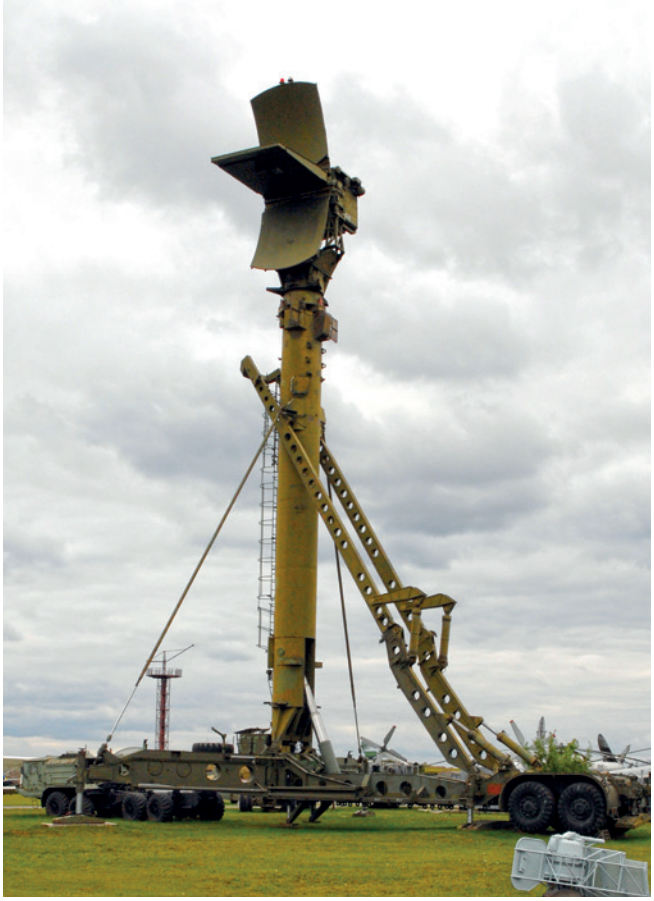
With development well under way, initial industrialization of the missile began. It became very evident that the S-300P system would be very expensive. As a result, the Kremlin instructed Almaz to study a simplified, low-cost version of the system that could also be sold to the Warsaw Pact countries. The initial proposal for the Orsha system was prepared in 1978. In the event, Orsha never proceeded beyond design studies.

As a result of the final S-300P trials at the GNIIP-10 proving ground at Sary Shagan, it was formally approved by the government of September 3, 1979 a little over a decade after the program had begun.

The basic combat unit of the S-300P system was the battalion (*divizion*) which would typically have four fire units (*puskovoy kompleks*) each with three 5P851 towed launchers and a single F3 operator's station for a total of 12 launchers per battalion. The battalion headquarters had a single 5N63 (Flap Lid) engagement radar, a 5N66 (Clam Shell) low-altitude surveillance radar, and an automated command post to link the battalion to higher formations.

An S-300P regiment (ZRP: *zenitniy raketniy polk*) would typically have three battalions, a headquarters battalion, and a technical battalion. The headquarters battalion contained the regiment's long-range surveillance radars such as the 5N64 (Big Bird). The 5N64 was originally deployed in a semi-static configuration with its massive antenna mounted on top of three electronics shelters. It was connected to the launcher battalions via a radio link. The regimental command post was based around a 5K56 command shelter.

The air defense missile brigade (ZRBr: *zenitnaya raketnaya brigada*) came in two basic configurations; a mixed brigade that could consist of a varying mix of S-300P and other types of SAM battalions, and the homogenous brigade equipped only with the S-300P. A typical PVO-Strany brigade in the 1980s consisted of three battalions of the S-200 and six battalions of the S-300P. This type of mixed brigade used the S-200 battalions for high-altitude, long-range engagements and its S-300P battalions for low-altitude, medium-range engagements. The brigade headquarters used automated control systems such as the Senezh (5S99M), Senezh-M (5S99M-1), Baikal (5N37), and Baikal-1 (73N6). These linked the launch battalions within the brigade as well as connecting the brigade to the national air defense network.


S-300P battalions deployed as part of the S-50 system around Moscow typically used the 40V6M masts for their radars. This is an example with the 5N66 (Clam Shell) surveillance radar. (Jim Kinnear)

By the end of 1980, about 12 S-300PT battalions were delivered. Training for the new system began at Sary Shagan in 1979 and was extended to the PVO-Strany training ground at Kapustin Yar in late 1980. The first four S-300PT battalions with the 562nd and 791st ZRP began deployment at former S-25 Berkut bases of the 1st PVO Special Missions Army along the Moscow ring road. They were followed by deployments in Nikolayev, Novosibirsk, Riga, and Severodvinsk in 1980, Kaliningrad and Kuibishev in 1981, and Sverdlovsk in 1982. By 1982, the S-300PT had been deployed at 54 sites near eight cities. Of these, 24 sites were former S-75/S-125 launch sites converted to the new S-300PT. Nineteen of the sites were former S-25 sites around Moscow and eight were entirely new sites, mainly near Riga in Latvia that shielded Leningrad from attacks along the Baltic axis.

The improved 5V55R with TVM guidance was formally adopted for service by government decrees on October 30, 1981; it was called SA-10B by Western intelligence. The upgraded system armed with the 5V55K and 5V55R missiles was designated as S-300PT-1. The first battalions equipped with the upgraded 5V55R missile were deployed with the 146th ZRBr in Severodvinsk in February 1981. Extended-range versions of both missiles were introduced later into service as the 5V55KD and 5V55RUD (D: *dalniy*: long range).

S-300PS Volkhov M6

The effort to shift the S-300P to a mobile configuration was codenamed Volkhov M6. The KBSM design bureau in Leningrad chose the MAZ-543M heavy 8x8 truck as the basis for the system's TEL (transporter-erector-launcher). This required a substantial redesign of the 5P851 quad launcher assembly to lighten it enough to be carried by the truck.

Factory tests of the mobile 5P85S TEL began in November 1980 and the state trials at Sary Shagan began in December 1981. The Bolshevik plant in Leningrad eventually produced about 640 5P85S standard TEL in 1972–93, while about 1,300 5P85D auxiliary TELs were assembled at various factories. As in the case of the TEL, the engagement radar was mounted on an MAZ-543M truck as the 5N63S. Assembly of the radar components on the MAZ-543M was undertaken at the Gorkiy plant in Novoye Sormovo. Likewise, other elements of the system were mounted on various truck chassis depending on their size.

The mobile version of the system was designated as S-300PS (S: *samokhodniy*: self-propelled) when adopted for service in 1983. The slow pace in deploying the mobile version was due to the need to modernize the existing missile bases to accommodate the larger number of heavy trucks associated with the new system.

By the time of the disintegration of the USSR at the end of 1991, there were about 230 S-300P battalions in service in 36 regiments and 28 brigades. About 70 of the battalions were the semi-mobile S-300PT configuration and 160 were the mobile S-300PS.

S-50 Moscow Defense Ring

The old S-25 Berkut system had remained in operation around Moscow through the 1970s by which time it was completely obsolete. A new requirement was issued for the new S-50 system to replace the 56 S-25 regiments around Moscow along with a related S-51 system to create a defense ring around Leningrad. At the same time, a costly program was already under way to replace the old A-35 anti-ballistic missile system around Moscow with the new A-135 system. In consequence, the idea of developing an entirely new missile for the S-50 system was rejected as economically extravagant even by Soviet standards.

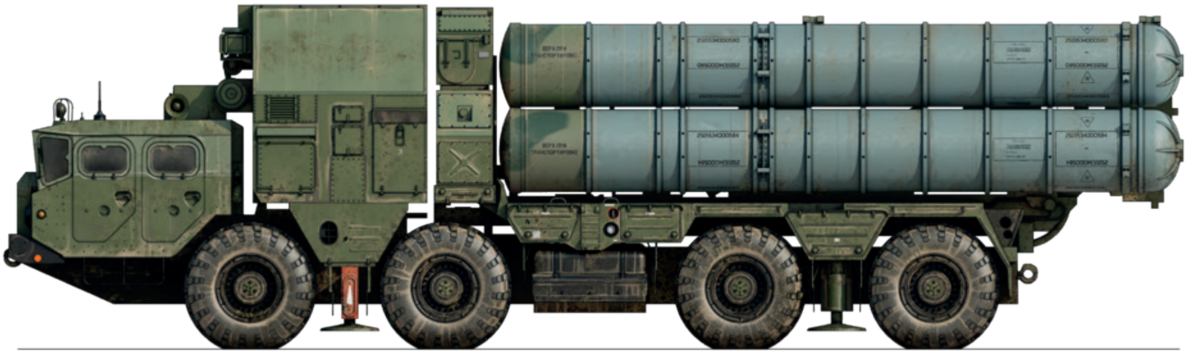
Instead, the idea emerged to deploy 56 S-300P battalions and two S-300V regiments to fulfill the S-50 requirement. The main aim of the S-50 program was to integrate the S-300 missile units into the Moscow air defense network since it had a much more elaborate array of radars and other surveillance equipment than available to typical S-300 regiments. Leadership of the S-50 program was offered to Boris Bunkin, the head of Almaz. Bunkin refused to lead the program, as it would have involved a cooperative effort with the rival Antey bureau. By this time, there was so much antagonism between the two chief designers of Almaz and Antey, Bunkin and Yefremov, that neither wished to lead the program. The Soviet defense minister, Dmitri Ustinov, had to intervene and, as a compromise, leadership of the S-50 program was undertaken by Nikolai V. Mokhin, the chief designer of the MNIIAP. The S-50 program was formally started on October 23, 1980.

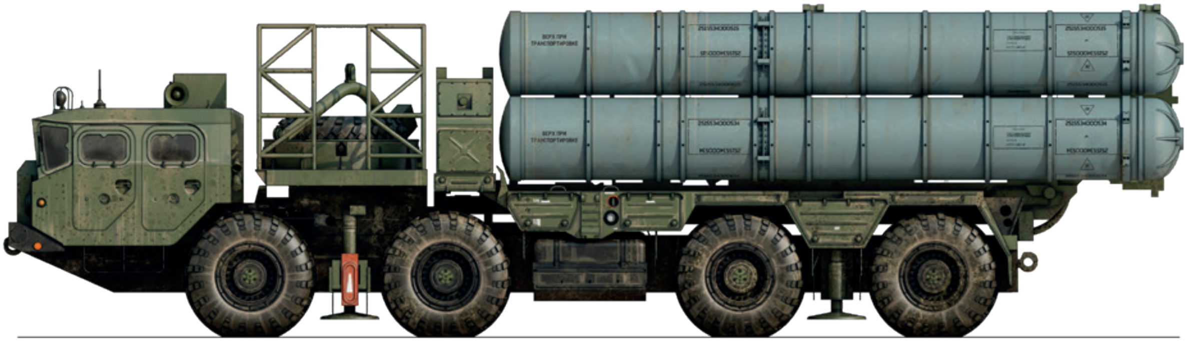
A

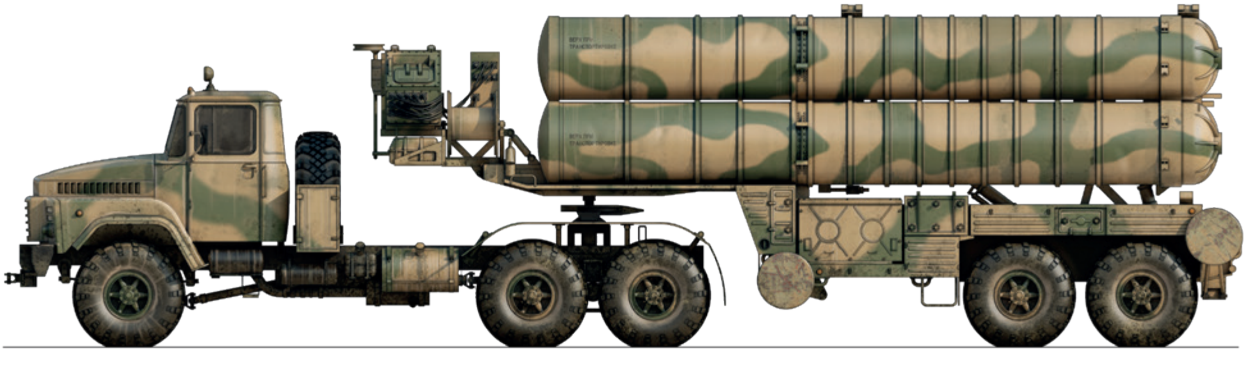
S-300P TRANSPORTER-ERECTOR-LAUNCHERS

This illustration shows the various TELs associated with the S-300PS Volkhov M6 system. Two versions of the TEL were developed, the 5P85S standard TEL and the 5P85D (*dopolnitelniy*: auxiliary) TEL. The standard TEL had an F3S control shelter behind the main truck cab supplemented by an auxiliary power unit (APU). The auxiliary TEL, sometimes called a slave TEL by Western intelligence, lacked the control cabin and APU. The mix of these TELs varied, sometimes a 2-to-1 ratio of auxiliary TELs per standard TEL and sometimes a 1-to-1 ratio. During combat operations, the auxiliary TELs were linked by cable to the control shelters on the standard TELs. The 5P85T semi-trailer option was developed for the S-300PM Volkhov M-6M (SA-20 Gargoyle) by placing the launcher assembly on a semi-trailer, towed by a KrAZ-260V tractor truck.

The TELs were finished in camouflage green (*zashchitniiy zeleno*) that in the late 1980s and early 1990s was designated as KhS-5146; a US match is FS 34098. The chassis was painted in gloss black including the wheel hubs. In the late 1980s, the Soviet Army began to adopt a factory-applied three-color disruptive camouflage scheme. The colors consisted of the usual dark green, with a pattern of gray-yellow (*sero-zheltiy* KhS-5146) with black patches. The 5P85T presented here is shown in the scheme on the vehicle displayed at the IDEX show in the United Arab Emirates during its expo debut. It was painted in overall gray-yellow with patches of camouflage green. These export display schemes are often peculiar to the exhibition and are not reflective of Soviet/Russian service schemes.







One of the distinct problems with deploying the S-300P in the Moscow area was that the S-25 missile sites were often hidden in forest clearings, edged with tall pine trees. When the S-300P was deployed at these sites, the forests created an unacceptable dead-zone if the usual engagement and surveillance radars were positioned on the ground. The solution was to mount the radars on massive semi-mobile towers. The 40V6M masts came in three heights: 24, 29, or 39 meters. The other main challenge was to automate data transfer for the scattered S-300P regiments into the Moscow air defense system. This involved the use of the Baikal-1 automated command post and the Osnova automated data handling system. Even before the S-50 infrastructure was ready, the PVO-Strany began deploying S-300P battalions around Moscow to provide some interim defense.

Testing of the S-50 system began in 1990 at Sary Shagan and it was formally adopted for service on April 25, 1994. In total, 18 S-300P regiments and two S-300V2 regiments were deployed with the S-50 system. The Leningrad S-51 system was never completed or deployed although a significant number of S-300P were deployed for the defense of the city. The first public display of the S-300P took place during the May 1990 parade on Red Square in Moscow.

Soviet strategic SAM production 1975–88*

	S-75	**S-125**	**S-200**	**S-300P**	**S-300V**	**S-300V**
	SA-2	**SA-3**	**SA-5**	**SA-10**	**SA-12a**	**SA-12b**
1975	3,000	1,730	1,200	20		
1976	2,500	1,830	1,200	30		1
1977	2,100	1,930	1,200	40	5	
1978	1,700	2,020	1,200	100	5	
1979	1,500	2,110	600	120	10	
1980	1,300	2,210	600	240	15	1
1981	1,100	2,000	600	600	15	1
1982	1,100	1,500	600	900	15	2
1983	700	1,300	600	1,800	20	5
1984	700	1,000	600	2,000	50	10
1985	700	1,000	600	2,000	150	15
1986	700	1,000	600	2,000	200	20
1987	500	800	300	3,000	300	20
1988	500	500	250	3,500	350	20
Total	**18,100**	**20,930**	**10,150**	**16,350**	**1,135**	**95**
Export**	3,865	10,435	555	0	0	0

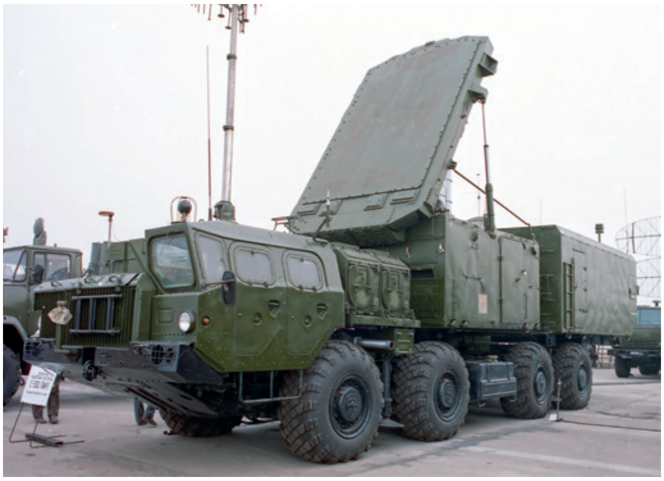
**Source:* "Soviet Military Production 1975–1988," US Interagency Intelligence Memorandum, September 1989

**Number of missiles exported from the total above

The Second Generation: S-300PM Volkhov M-6M (SA-20A Gargoyle)

The deployment of the S-300PS system finally fulfilled the basic requirements envisioned for the system in its original requirements from 1969. Due to the interval between the original plans and its eventual realization in the mid-1980s, the threat had changed and Soviet electronics technology had considerably advanced. Under the new Reagan administration, the

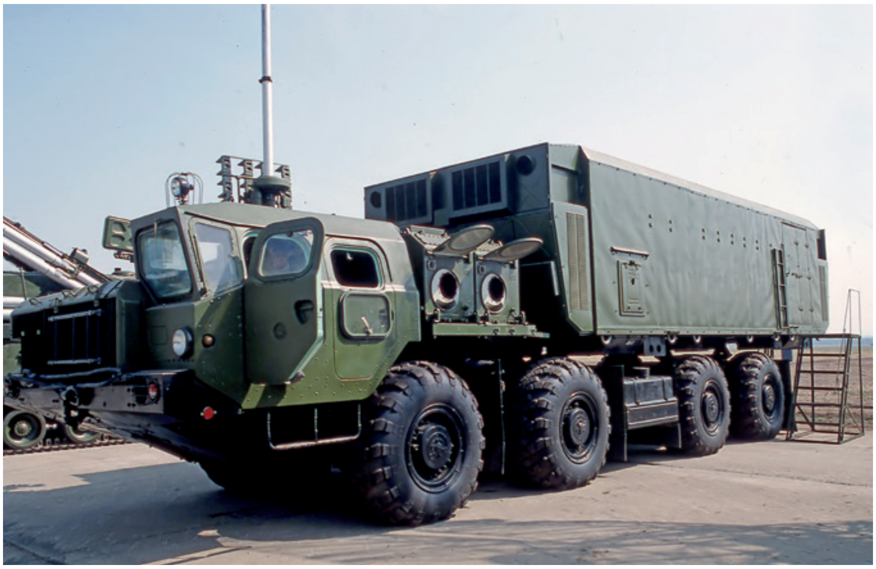
US Strategic Air Command began to modernize with the B-1B Lancer and B-2 Spirit bombers, as well as the AGM-129 stealth cruise missile. Soviet electronics technology was rapidly changing especially in microprocessor technology, which increased processing speed about tenfold during the 1970s.

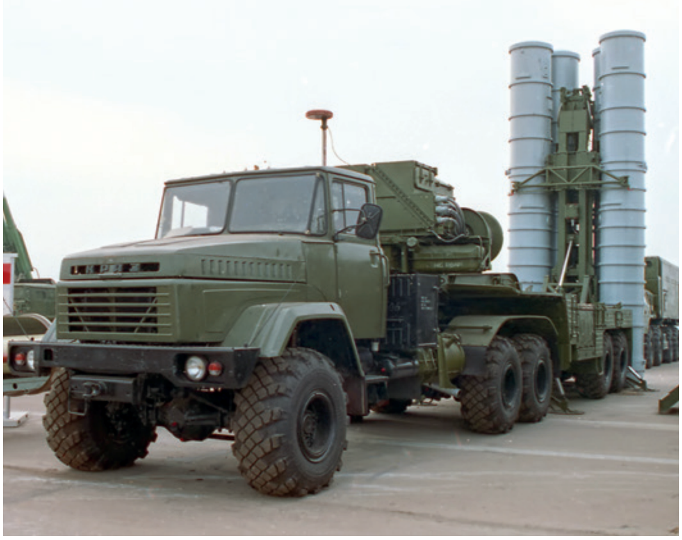

The S-300PM introduced the improved 30N6 (Flap Lid B/Tomb Stone) engagement radar. This system was known as the S-300PMU-1 in its export configuration.

As a result, on January 11, 1983, the Kremlin authorized the start of a deep modernization of the S-300P. The new requirements included features to deal with tactical ballistic missiles and aero-ballistic missiles traveling at speeds up to 1,800m/s; extension of the effective range of the system to 150km; and improved radars to engage stealth targets. An underlying aim of the program was to reduce the high manufacturing cost of the system while at the same time lowering operating costs by reducing the number of personnel needed to operate it. The upgraded system was known internally under the codename Volkhov M-6M.

The new system included a substantially improved missile, Fakel's 48N6. Although similar in appearance to the previous versions, the new missile was designed to be cheaper and easier to produce. In addition, it extended the range to 150km.

Two launcher configurations were available for the system. The 5P85SM on the MAZ-543 was a modestly upgraded version of the 5P85S mobile launcher used in the S-300P system. However, the new 5P85T semi-trailer option was developed by placing the launcher assembly on a semi-trailer, towed by a KrAZ-260V tractor truck. The engagement radar vehicle was upgraded as the 30N6 (Flap Lid B/Tomb Stone) that resembled the previous 5N63S (Flap Lid A) but which had completely upgraded electronics.


The 54K6 is part of the mobile 83M6 command system at battalion headquarters. The 83M6 pairs the 54K6 command post with the 64N6 (Big Bird) radar. The 54K6 includes a shelter on the rear of a MAZ-543M truck that serves to automate the data handling from the radar, maintain tracking of up to 100 targets, and distribute the data to lower commands.



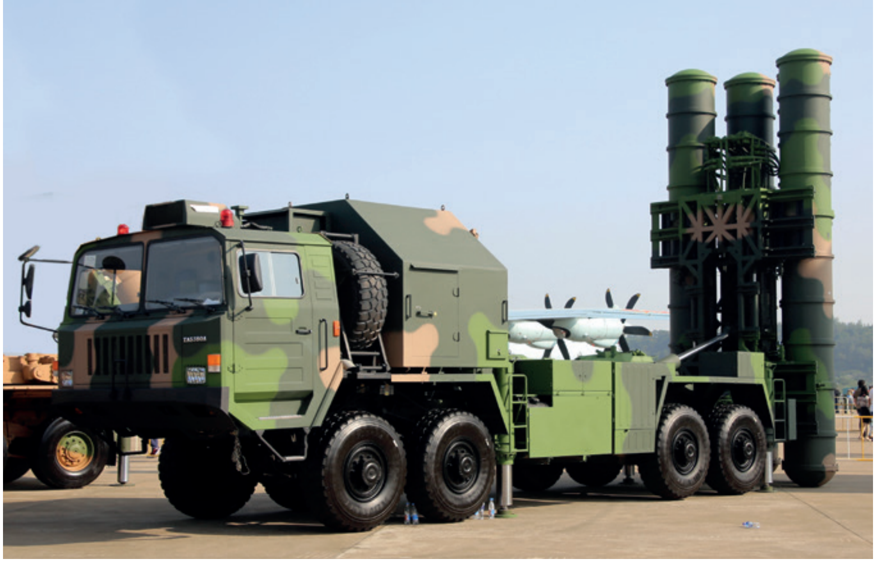
The S-300PMU-1 system offered two launcher options, including the new 5P85T semi-trailer consisting of a KrAZ-260V prime mover and a new semi-trailer launcher.

Factory tests of the new 35R6 (S-300PM) system were carried out from January 1985 to December 1987, and the state tests followed from June 1989 to October 1990 at Sary Shagan. A further set of tests were conducted near Murmansk on the Barents Sea in 1991. The S-300PM program underwent difficult times in the final years of the Soviet Union. Although the state tests were entirely successful, the turmoil in the Kremlin in 1990–91 and the dissolution of the Soviet Union led to a delay in formal Russian government acceptance of the S-300PM system until July 13, 1993. The new S-300PM battalions were deployed primarily on the inner ring of S-25 sites around Moscow as part of the S-50M program.

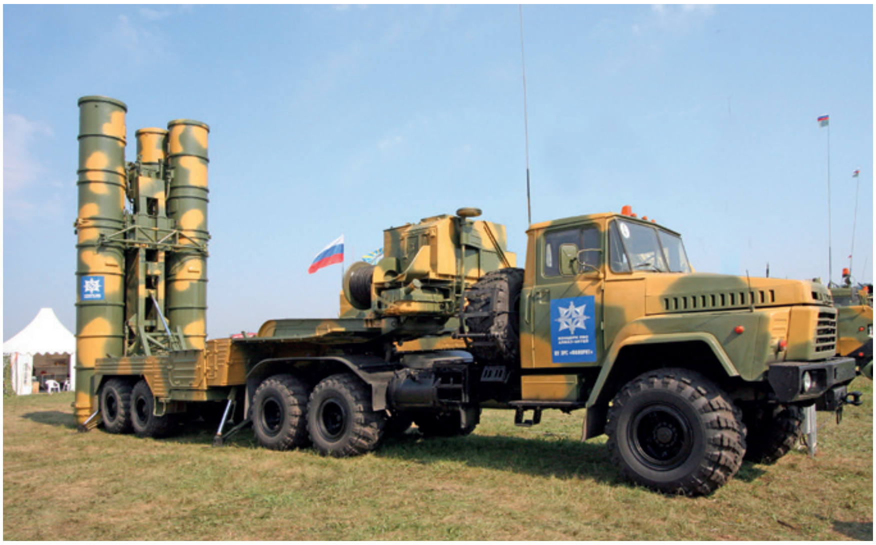
S-300PMU Export System

Development of an exportable version of the S-300P system began alongside the S-300PM in the early 1980s. This export system, designated as S-300PMU, was based on the earlier S-300P system and did not include the same interfaces into the Soviet air defense network. The system used the older 5V55 family of missiles, and did not include the new 48N6 missile. India was the first country to approach the Soviet Union about possible export in 1984. Although negotiations took place, the sale did not occur. The S-300PMU was cleared for production in 1988.

The Warsaw Pact was Moscow's main client for the sale of the S-300PMU, and talks began in 1985. The original plans anticipated that the Warsaw Pact countries would purchase only one or two battalions each, and so would lack



The strong similarity between the Chinese HQ-9 air defense system and the Russian S-300P suggests that technology transfer or reverse-engineering played a role in its development. The export version is known as the FD-2000.



The 5P85TE2 TEL of the semi-trailer version of the S-300PMU-2 Favorit system using the KrAZ-6446 Titan-01 (formerly KrAZ-260V) as the prime mover.

the long-range surveillance capabilities such as Big Bird radars found in Soviet regiments and brigades. Instead, the S-300PMU was deployed with the 36D6/ST-68U (Tin Shield) radar. Bulgaria was the first Warsaw Pact country to deploy the S-300PMU and received eight launchers in 1989. These were deployed near Bankya, west of Sofia, with the 1st Air Defense Missile Brigade (*1-va Zenitno-raketna brigada*). Czechoslovakia was the second country to receive the new system with 12 launchers deployed in Kačice with the 20th Air Defense Battalion, 71st Air Defense Brigade of the 3rd Air Defense Division (*20. protiletadlový raketový oddíl, 71.plrb, 3.dPVO*). These systems were subsequently transferred to Slovakia after the split-up of Czechoslovakia in 1993. The East German S-300PMU system was assigned to the 4351st Air Defense Missile Battalion of the 43rd Brigade (*Fla-Raketenabteilung-4351, 43. Fla-Raketenbrigade*) in Retschow. The battalion was on the verge of deployment and all of its equipment had arrived. However, the East German government agreed to Soviet demands that the equipment be returned to the USSR prior to German re-unification in 1990. Hungary was close to deployment of the S-300PMU but it was not completed by 1991 and so never deployed. Poland was the last country covered under the S-300PMU agreement but no deployment took place.

There had been no firm plans about the export of the S-300PMU outside the Warsaw Pact until the collapse of the Soviet Union. In the first years of the new Russian Federation, state funding for defense production was extremely shaky and salaries for personnel at the research centers and production plants was erratic at best. Starved of funds, the Russian defense industry hoped that export orders might bridge the gap until Russia got back on its feet.

After the Soviet collapse, Russia was saddled with several S-300PMU battalions that had been manufactured for the Warsaw Pact. These were not designed to interface with the standard PVO-Strany network. In 1990, China approached the Kremlin about the purchase of the S-300PMU and a decision was made to dump the surplus battalions at bargain basement prices. This sale was controversial in Russian defense circles due to concerns that the Chinese would reverse-engineer the S-300P. Deliveries of the S-300PMU to China began in 1993 including 32 launchers and 120 5V55R missiles.

Curiously enough, the next customer for the S-300P system was the US Army. In 1994, the United States purchased fire control elements of the system from newly independent Belarus, and more than a dozen 5V55 missiles from Ukraine for technical evaluation.

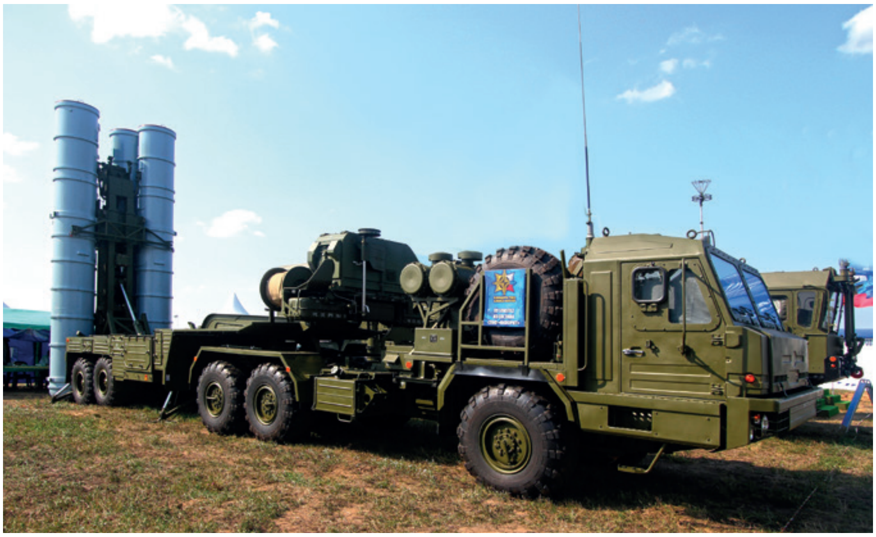
The S-300PMU was first publicly offered for export at the Moscow air show at Zhukovskiy in the summer of 1992. In 1993, permission was granted for a live-fire demonstration of the S-300PMU at the IDEX weapons show in the United Arab Emirates. An S-300PMU system was sent to the Maqatra ranges of the UAE armed forces in Abu Dhabi where demonstrations were conducted by troops of the 612 ZRP from the Moscow air defense district.

To further entice export clients, the S-300PMU continued to be upgraded with features developed earlier for the Soviet S-300PM. The next iteration of the export version was the S-300PMU-1 that included the 48N6E (E: *eksportniy*: export) missile. This was cleared for production in 1993.

The Severniy Zavod in St. Petersburg, one of two Russian plants manufacturing the 48N6 missiles, received its last Russian state order in 1994 for only 62 missiles. It sold an additional batch of 5V55R missiles to China in 1995. These were desperate days for the Russian defense industry and China paid for the missiles in barter goods with consumer products that were distributed to the Russian plant workers in lieu of wages.

The first export customer for the new S-300PMU-1 was China which signed a contract in 1994 for four battalions including the new 48N6E missiles. In the summer of 1998, the Chinese began advertising their HQ-9 air defense missile system for export which bore a strong resemblance to the S-300PS. It is not clear whether this system was reverse-engineered from the original deliveries or based on technology transfers from Russia. In the event, China signed another contract for four S-300PMU-1 battalions in December 2001 that were delivered in 2003–04. This brought the Chinese orders to 32 S-300PMU and 64 S-300PMU-1 launchers.

The next customer for the S-300PMU-1 was Cyprus. The Greek Cypriot National Guard wanted to upgrade its air defense in connection with the deployment of Greek air force F-16 fighters to the Paphos air field and NATO countries were not keen on selling their systems for fear of antagonizing



The second configuration of 5P85TE2 TEL of the S-300PMU-2 Favorit system unveiled in 2011 uses the BAZ-6402 prime mover instead of the KrAZ-260. The 5P85TE3 TEL of the S-400 Favorit system is essentially similar to this.

Turkey. The Cypriot order for the S-300PMU-1 was finally concluded in January 1997 for 8–12 5P85T launch vehicles and 96–150 missiles at a cost of $218 million. Before the system was deployed, the Greek government bowed to NATO pressure. Under a compromise agreement, the S-300PMU-1 was deployed to Crete. Cyprus received short-range Tor-M1 air defense systems from the Greek inventory instead.

Vietnam purchased two battalions of S-300PMU-1 in 2001 to start rejuvenating its obsolete arsenal of S-75 air defense missiles. Kazakhstan received eight battalions of the S-300PMU in 2000, in payment for Russian lease of the Baikonur spaceport.

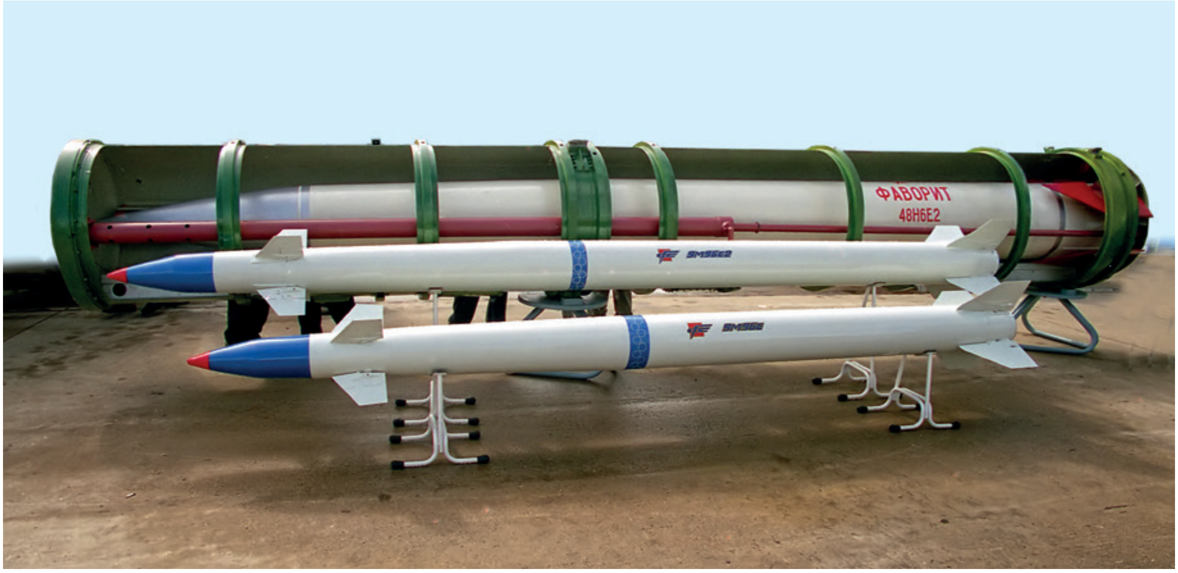
S-300P missile comparative data

GRAU Designation	5V55K	5V55R	48N6	48N6D	48N6DM	40N6
Initial production	1975	1981	1990	1997	2011	2018
Length (mm)	7,250	7,250	7,500	7,500	7,500	7,500
Diameter (mm)	514	514	519	519	519	519
Weight (kg)	1,480	1,665	1,799	1,835	1,835	1,893
Warhead weight (kg)	130	130	143	180	180	180
Max. range (km; vs. aircraft)	47	75	150	200	250	380
Max. range (km; vs. missile)	–	–	–	40	60	150
Min. range (km)	8	5	5	3	3	5
Max. altitude (km)	25	5	27	27	30	40
Min. altitude (km)	.025	.025	.01	.01	.01	.01
Max. speed (m/s)	2,000	2,000	1,900	2,000	2,000	2,000
Max. target speed (m/s)	1,160	1,200	2,800	2,800	4,800	4,800

Catering to the Export Market: S-300PMU-2 Favorit (SA-20B Gargoyle)

In the wake of the 1991 Gulf War, Almaz began examining the lessons of the conflict, especially the influence of tactical ballistic missiles (TBM) such as the R-17 Elbrus (SS-1b Scud). This issue became more urgent in the early 1990s when potential export clients began to ask Almaz whether the S-300PMU export system could deal with ballistic missiles as well as the US Army's MIM-104C Patriot PAC-2 missile that had entered service in 1991. This new mission led to the development of the S-300PMU-2 Favorit. By 1992–93, development funding from the Russian government was evaporating, and much of the work had to be done using scarce internal funds with the promise that eventual exports would pay off any debts incurred.

The primary improvement in the 35R6-2 Favorit system was the adaptation of the warhead to better deal with the hardened warhead casings typical of TBMs. The solution was a pre-fragmented warhead casing to improve the penetration of the TBM's warhead casing, causing it either to explode or to deflagrate and burn out during re-entry. While the focus of the program was on the improved 48N6D (export: 48N6E2) missile, a number of other improvements were incorporated into the system. Favorit was intended to be easier to integrate into various air defense systems including foreign systems. It incorporated newer sensor options such as the 96L6 radar. Its maximum range against aircraft was extended from 150 to 200km. Its fire control algorithms were improved to permit simultaneous tracking of both aircraft and ballistic missile targets. The new system permitted six battalions to engage up to 36 targets with 72 missiles.



Almaz began offering the smaller 9M96E and 9M96E2 as short-range supplements to the larger 48N6E2 with the Favorit series. These missiles also formed the core of the S-350 Vityaz.

Since the Sary Shagan proving ground was now located outside of Russia, Almaz turned to the PVO-Strany training ground at Kapustin Yar for the tests. The tests began on August 10, 1995 against R-17 Elbrus (Scud B) missiles. The tests were successful enough that the S-300PMU-2 Favorit system was unveiled at the Moscow air show in the summer of 1997.

The Favorit system was controlled by the 83M6E command system that included the 54K6E2 control post and the 64N6E2 surveillance radar. A battalion typically included a 30N6E2 engagement radar, 12 TEL of either the 5P85SE2 or 5P85TE2 type and the 48N6E missiles.

It took some time for Russian firms to have systems for sale. By the mid-1990s, Russian state orders had evaporated. The impoverished design bureaus and manufacturing plants saw their workforce disappear when wages dried up. Factories outside Russia such as in Ukraine stopped providing key components. Ukrainian sources later claimed that its factories were responsible for about 40 percent of the S-300P system, though this figure was disputed by the Russians.

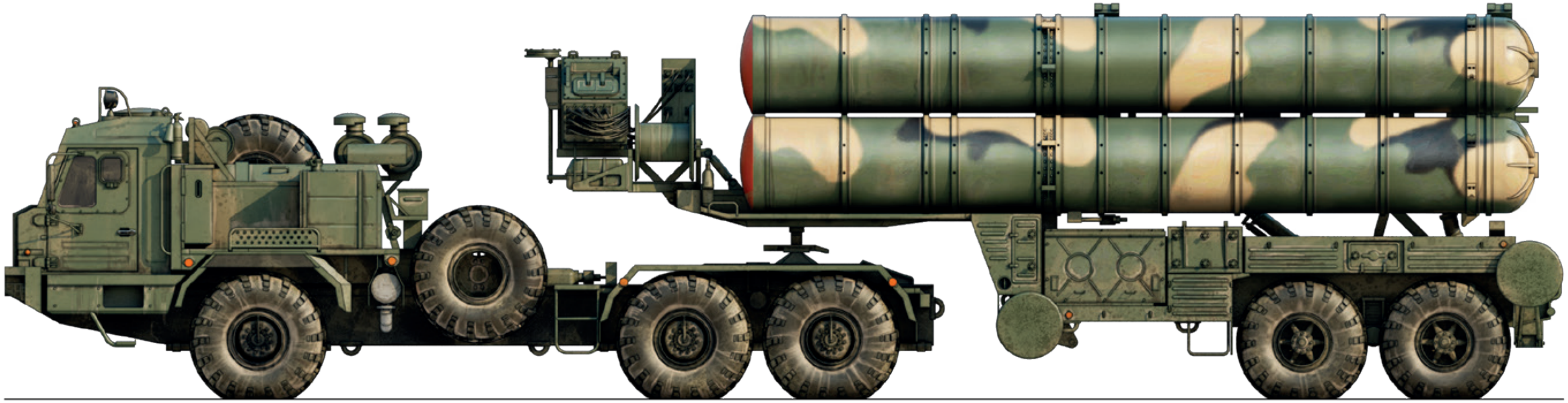
China again redeemed the situation with an export order in 2004 for eight battalions of S-300PMU-2 Favorit. The order was valued at nearly $1 billion, and 32 launchers and other associated equipment were delivered in 2008–09. Subsequent orders for Favorit included an Algerian contract for eight battalions in 2006.

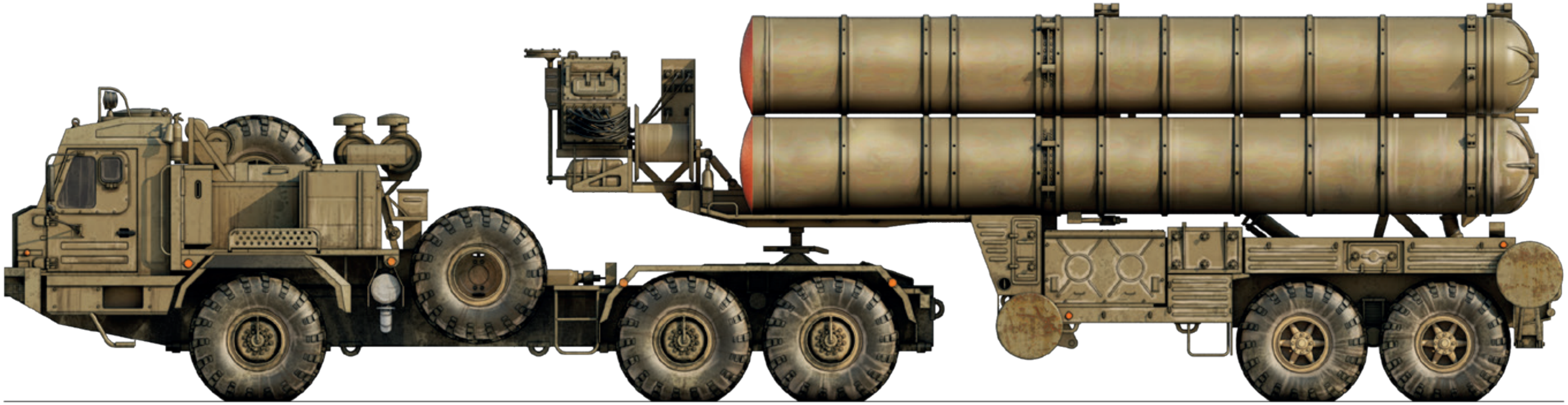
B

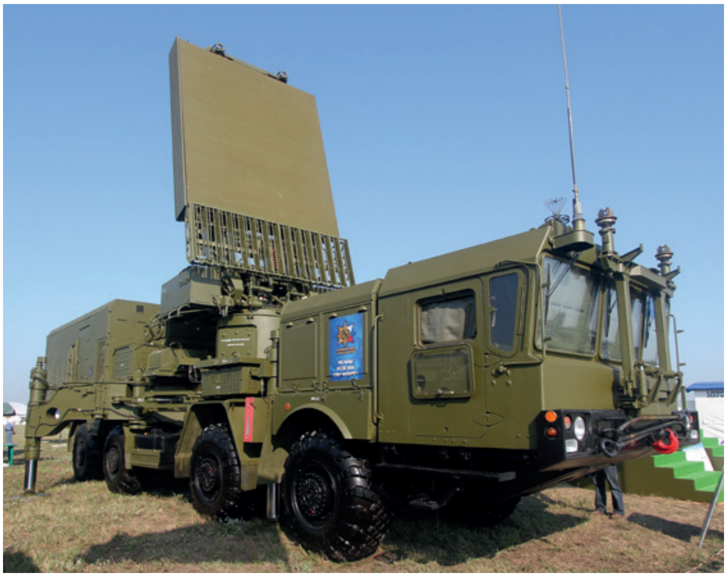
S-300PMU-2 FAVORIT EXPORTS

1. Iranian Air Force S-300PMU-2 Favorit. Iran signed a $800 million contract with Russia in 2010 for the S-300PMU-2 Favorit system with deliveries beginning in April 2016 and finishing in October 2016. The systems were declared operational in the summer of 2017. The TELs were delivered in standard Russian camouflage green with some missile TPKs in the three-tone camouflage of green, gray-yellow, and black.

2. Algerian Air Force S-300PMU-2 Favorit. Algeria ordered the S-300PMU-2 Favorit from Russia in March 2006 with deliveries in 2015. Some of the first battalions were deployed to defend the Mers-el-Kébir naval base. The color scheme of the Algerian vehicles appears to be a khaki color, darker and browner than the usual Russian gray-yellow.





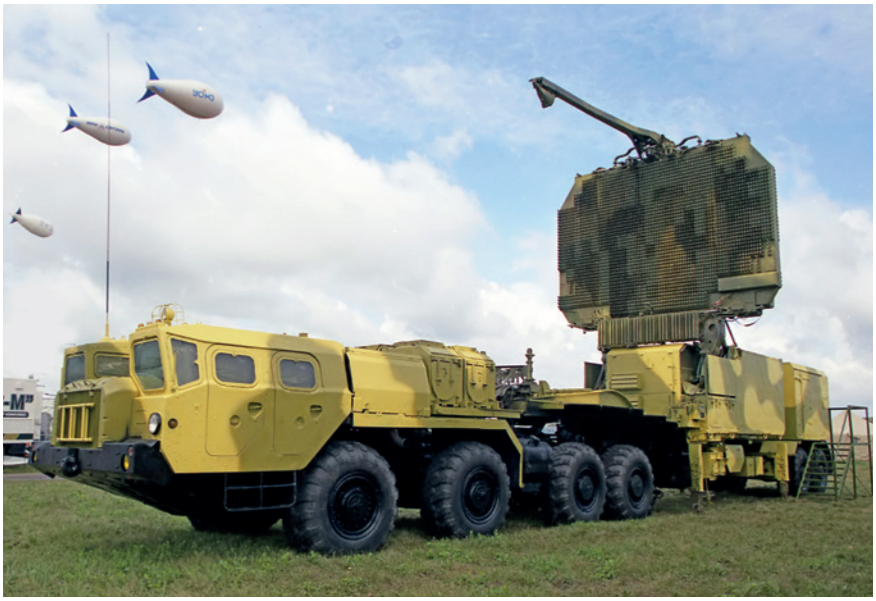


The 96L6 (Cheese Board) is one of the new phased-array surveillance radars introduced with the S-300PMU-2 to replace earlier radars. It is manufactured at the Lianozovo Electromechanical Plant and was accepted for service in 2008. It is mounted on the MZKT-7930 truck.

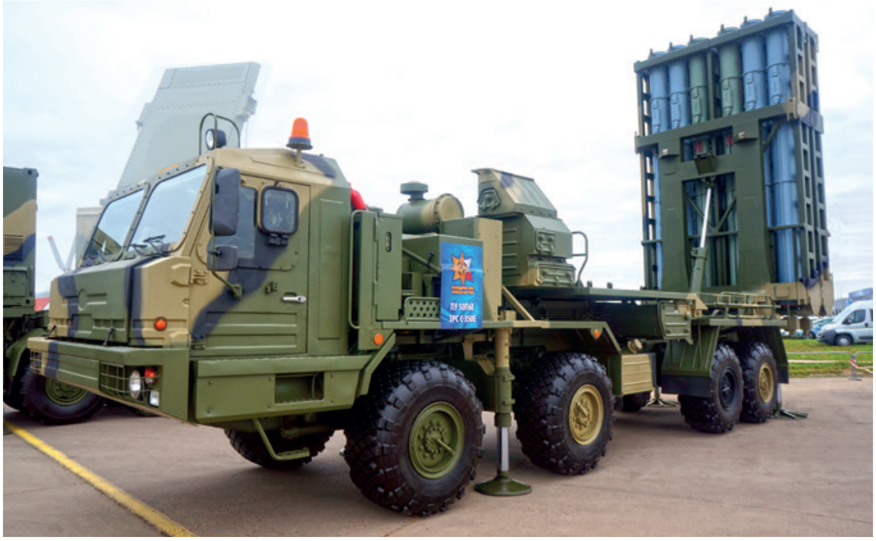
In 2010, Azerbaijan purchased two battalions of S-300PMU-2. These first saw combat in the October 2020 conflict between Azerbaijan and Armenia over the disputed Nagorno-Karabakh region. Armenia had older S-300PS systems from the Soviet era. The Azeri forces attacked the Armenian SAM sites using Israeli Harop loitering missiles and Turkish Bayraktar TB2 armed drones, destroying several Armenian radars and launchers. On the night of October 1/2, 2020, Armenia claimed to have shot down three Azerbaijani drones bound for Yerevan with their S-300PM systems. On October 18, 2020, Azerbaijan claimed that one of their S-300PMU-2 battalions shot down an Armenian Sukhoi Su-25 trying to attack the Azerbaijani forces in the Jabrayil. These incidents were the first recorded combat successes of the S-300P system.

S-350 Vityaz (SA-28)

The S-350 requirement was released in the early 1980s as a replacement for the S-300P family. With the decision to proceed instead with the S-400 as described below, the S-350 designation was re-used for a supplementary system. The S-350 Vityaz (Knight) air defense missile system was intended as a short-range system based on the new 9M96 family of missiles. Fakel began design work on this missile in 1988 to provide better performance against cruise missiles than the relatively large 48N6 missile developed for



The 64N6E2 (Big Bird) is the latest version of the series of long-range surveillance radars developed by NIIP for the S-300PMU-2 system. This is used in regimental and brigade headquarters for target detection and surveillance.



A 50P6 TEL of the S-350 Vityaz system during its public debut at the Moscow airshow in August 2013. It is much smaller than the S-300P/S-400 TELs since it uses the smaller 9M96 family of missiles. It is based on the BAZ-69092-012 truck chassis.

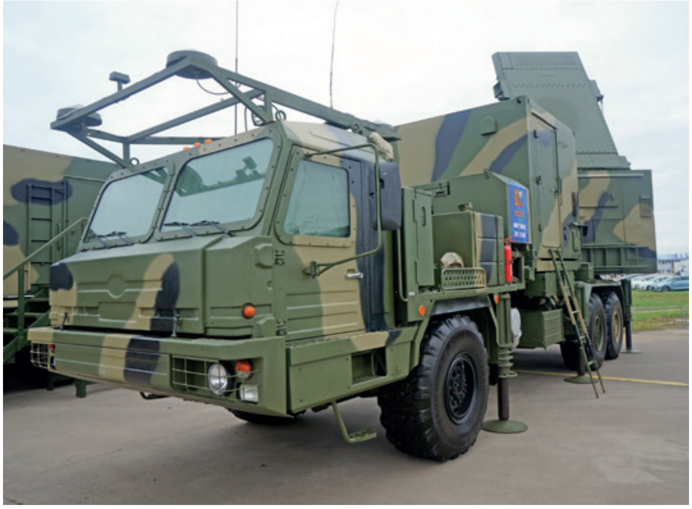
the S-300PM. This was similar in approach to the US Army's MIM-104F PAC-3 missile in the Patriot system. Four of the smaller 9M96 missiles could be accommodated in the same launcher space as a single 48N6 missile. The demise of the Soviet Union put the program into limbo.

The program was dusted off in 1994 when the South Korean government approached the Kremlin about possible defense technology transfers to pay off Russia's substantial commercial debt to Korea. The Korean SAM was called the Chulmae-II KM-SAM (Iron Eagle 2 Korean Medium SAM). The baseline missile for the KM-SAM was derived from initial Fakel work on the 9M96.

Russian interest in the 9M96 missile was revived for two applications. As is described below, it became part of a package of missiles suitable for the new S-400 program. Secondly, it also formed part of a repackaged, simplified, offshoot of the S-300P system called the S-350. The S-350 was intended to provide the capability for full hemispheric defense rather than being limited to sector defense as was the case with the S-300P. In addition, the size of the missile permitted a launcher to accommodate four times as many missiles in the same space, an attractive feature when repelling a massed cruise missile attack. Eventually, three missiles were developed for the S-350 system: the 9M100 with a range of 10–15km, the 9M96 with a range of 60km, and the 9M96D with a range of 150km. Rather than using TVM guidance, these missiles used an active-radar homing system for the terminal phase of the engagement.

The public debut of the 9M96 missile took place at the August 1998 Moscow air show as a potential supplement to the S-300PMU-1. The 9M96 missile began tests at Kapustin Yar in 1999. The revived S-350 program was delayed by the lack of adequate funding that did not begin in earnest until 2007. The aim at this time was to use the less expensive S-350 instead of the new S-400 to replace the older elements of the S-300P system deployed in the Moscow area with the S-50 system that were scheduled for replacement around 2015. Early tests of the missile in 2011 uncovered problems with the missile's new active-radar seeker.

The Vityaz was publicly unveiled to President Vladimir Putin on June 20, 2013 at a ceremony at the Obukhov plant in St. Petersburg that was the assembly facility for the system. The Russian government subsequently offered the system for export as the S-350E and it saw its public debut at the August 2013 Moscow



The 50N6 phased-array engagement radar vehicle on the BAZ-6909 truck chassis of the S-350 Vityaz system.

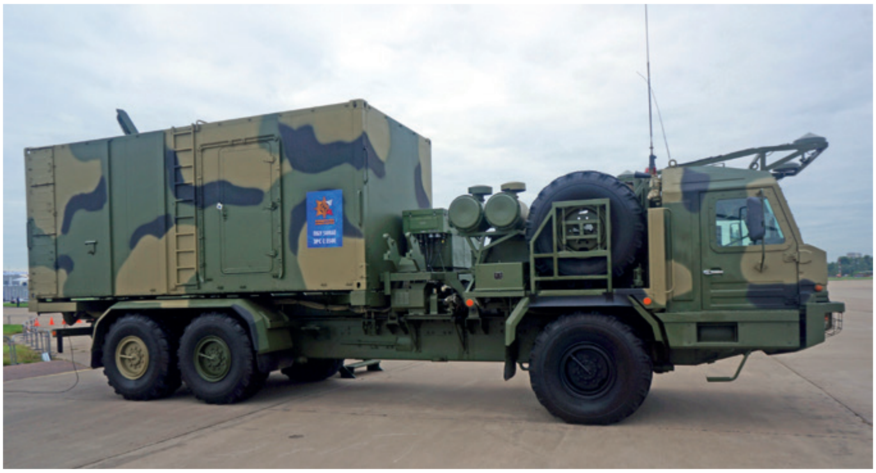
air show. The first Russian battalion was delivered in December 2019 under the system designator 50R6. The initial equipment was sent to the Zhukov Air and Space Defense Academy in Tver to begin training crews. The Russian government funded the first four serial-production battalions of the Vityaz in the 2020 defense budget.

The S-350 Vityaz is deployed in battalions consisting of a 50K6 command post, one or two 50N6 fire control radars, and up to eight 50P6 TELs. The Russian version of the system uses the new BAZ-6909 Voschina-1 family of trucks but the export version is offered with other trucks including the MZKT-7930 Astrolog type. Naval systems using the 9M96 missiles, the Poliment-Redut and Resurs, are also being developed for use on corvettes and frigates.

The Third Generation: S-400 Triumf (SA-21A Growler)

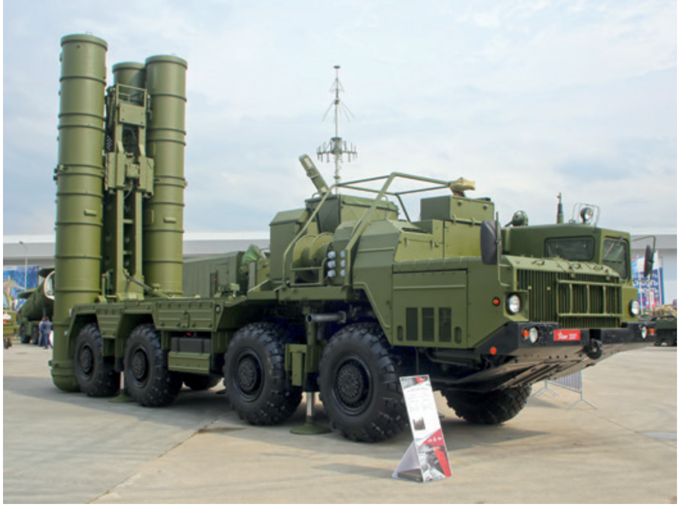
The PVO-Strany had begun steps to replace the old S-200 missile system in the late 1970s. The was undertaken under the rubric of S-400. The first scheme was rejected by a state commission as being too expensive and failing to address the new threat environment dominated by low-altitude cruise missiles. The S-400 requirement was revisited in the late 1980s under the codename Triumf (Triumph) to deal with aircraft targets at long range as well as cruise missiles and new stealth aircraft. Government approval to start the program was issued on August 22, 1991, a day after the coup against Mikhail Gorbachev had collapsed. Regardless of the official approval, the turmoil in Russia meant that it went into limbo due to the collapse of Russian state funding for defense programs.

The S-400 program limped along through the 1990s, largely due to independent initiatives of different Russian missile and radar design bureaus. The program was officially revived by a government decree on July 7, 1999.



The 50K6 command post vehicle of the S-350 Vityaz system.

The original mission of replacing the S-200 with a new long-range system was substantially reconsidered. Instead, the program aimed at reviving the S-300PM program with a second deep modernization. It took over the S-400 designation, even though it had little to do with the original requirements, since the new name was seen as an attractive marketing label for the export market to emphasize the degree of modernization of the S-300P system. The basic infrastructure of the S-400 remained very similar to the S-300P but virtually every component of the system was substantially redesigned.



The 5P85SE3 on the MZKT-543M (formerly MAZ-543M) truck is one of several TEL options for the S-400 Triumf system. This is an auxiliary TEL, lacking the command shelter behind the cab. The other self-propelled TEL for the S-400 system is the 51P6 based on the MZKT-7930 truck.

Another aspect of the program was the need to reindustrialize the Russian missile industry. Aside from the loss of many supporting design bureaus and plants in the former Soviet republics, many Russian plants had closed or had stopped work on defense products due to a lack of defense funding through the 1990s. On August 26, 2000, the Kremlin authorized a new program to rejuvenate the Russian missile industry in support of the S-400 program. Three major new facilities were built for missile system production, a new wing of the Obukhov plant in St. Petersburg, the modernized Avitek plant in Kirov and the NMP plant in Nizhniy Novgorod. These plants were ready by 2016. The Kremlin also decided to Russify the components, eliminating many of the systems that had been supplied from Belarus or Ukraine. For example, the familiar MAZ-543M trucks were largely replaced by the BAZ-6402 Voschina-1 family of trucks.

The Russian government also imposed a greater degree of centralization in the air defense industry in 2002 by placing the rival Almaz and Antey firms under a single corporation as well as 44 other industrial and research enterprises and organizations. By 2020, Almaz-Antey emerged as Russia's largest defense firm, in no small measure due to its success with the expensive S-300P in the export market.

The S-400 Triumf was formally adopted for service by a government decree on April 28, 2007 under the GRAU designation 40R6. The first Triumf system was delivered on August 6, 2007 to the training base in the Astrakhan district. The first operational battalion was deployed with the 606th Guards Air Defense Regiment near Elektrostal in the Moscow district. In August 2011, the production of the S-300P system ended in anticipation of switching completely to the production of the S-400. An extended-range version of the 48N6D (48N6E2) with 250km maximum range was developed in the late 1990s as the 48N6DM (48N6E3) and first displayed at the Moscow Air Show in August 2011.

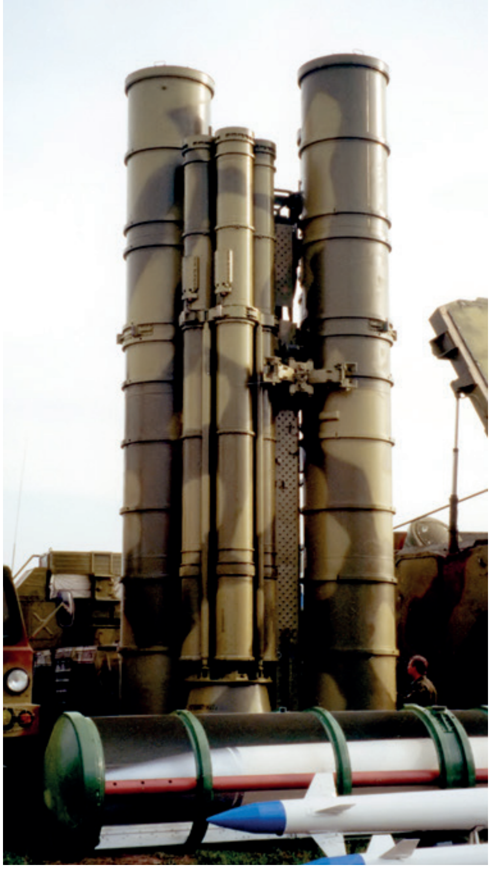
The next stage of S-400 development was the addition of the long-delayed 40N6 missile to the S-400's missile options. This was an important advance for the program since the intention was to use the S-400 to replace the long-range S-200 in Russian service. The 40N6 missile is similar in size and weight to the 48N6DM, but optimized for long-range engagements against aircraft.

It has a maximum range of over 400km against certain aircraft types. The initial tests began in 2014, and state trials concluded in September 2018. In October 2018, the 40N6 was accepted for service. Russian accounts indicate that the missile can be used with either the S-400 or S-500 systems.

Production of the S-400 permitted a significant modernization of Russian national air defenses. The old S-200 long-range system was retired around 2015. The last S-300PT systems with the 5P851 trailer launcher were retired in 2017 although they remained in service in other former Soviet republics such as Ukraine. By 2020, the Russian force totaled about 120 battalions of which about 50 were the older S-300PS and S-300PM, and about 70 were the new S-400. As a result, S-400 constituted a little more than half of the Russian force. In 1996 Russia began a process of consolidation of the air force and PVO-Strany. The most recent iteration of this process was the formation of the Russian Aerospace Forces (VKS) in August 2015.

The Triumf system is commanded by the 30K6 control system including the 55K6 command post and the 91N6 surveillance radar. The battalion deploys 12 TELs of the 5P85SM2-01, 51P6, or 5P85TM types and is armed with the 48N6M and 48N6DM missiles. The export versions of these missiles have the usual export suffixes, so the export version of 48N6M is the 48N6E2 and the 48N6DM is the 48N6E3. The S-400E with the 51P6 TEL has the option to launch the 9M96E family of missiles as a low-altitude, high-volume supplement.

The S-400 was deployed overseas to Syria in the wake of a Turkish shoot-down of a Russian Su-24 strike aircraft in 2015. The first Russian S-400 battalion was activated at the Khmeimim Air Base in Latakia province. In April–July 2017, a second S-400 battalion was deployed 13km northwest of Masyaf, in Hama province. Related to this, in late 2018 Russia began to supply Syria with three battalions, apparently the older S-300PM system. After a number of Israeli air strikes in 2019–20, Syrian officials criticized their S-300PM systems as ineffective against the Israeli aircraft and missile attacks. Although Syria has also complained about the failure of the Russian



The 9M96E family of missiles has been offered with the S-300PMU-2 Favorit and S-400 Triumf to provide a close-range/low-altitude supplement to the usual 48N6 missiles. Due to their smaller size, they are issued as a quad-pack with four missiles in the place of one of the larger 48N6 missile canisters. This is the prototype version with three launch tubes as displayed at the Moscow air show.

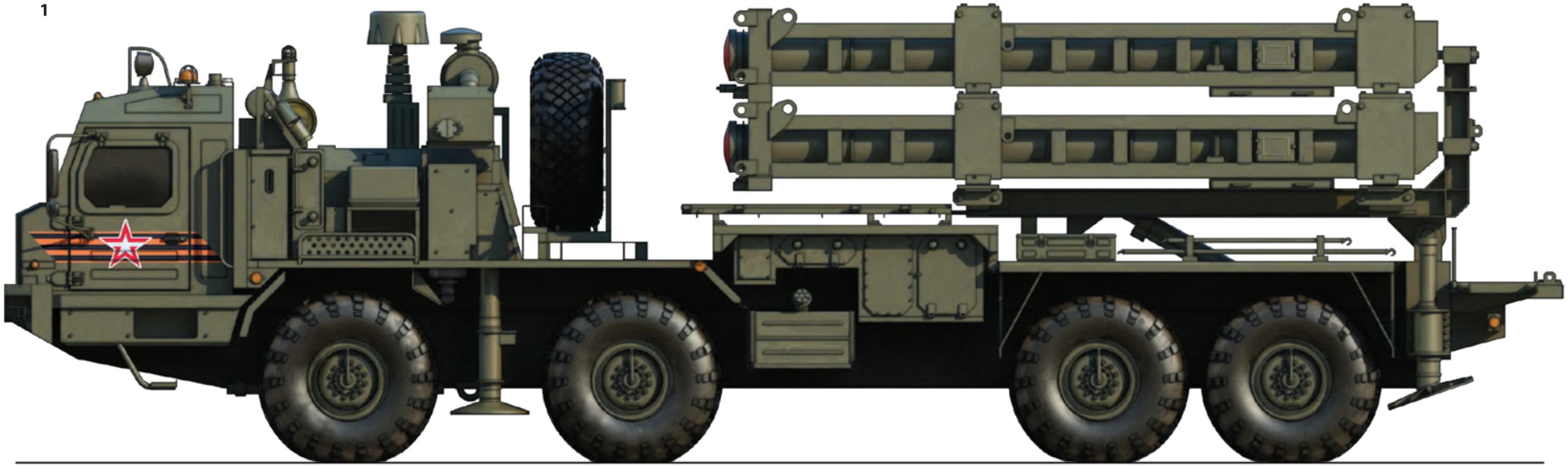
C

VITYAZ AND TRIUMF

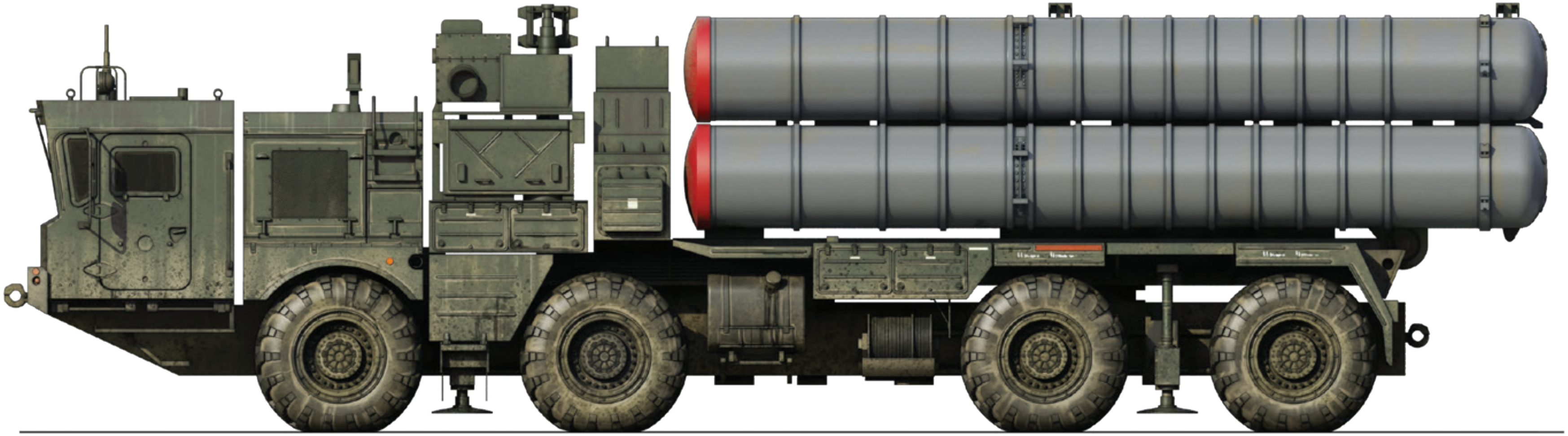
1. S-350 Vityaz, Russian Aerospace Defense Command, Moscow 2020. On April 4, 2013, the Defense Minister, Sergei Shoigu, announced that the armed forces would abandon the three-color camouflage and revert to the use of an overall finish of camouflage green. This particular vehicle took part in the June 20, 2020 Victory Day parade in Moscow celebrating the 75th anniversary of the victory over Nazi Germany. The orange and black elements of the parade insignia are based on the traditional ribbons of the Order of St. George (*Orden Sviatogo Grigoriya*) that had been abolished in the Soviet period and restored by Vladimir Putin in 2000.

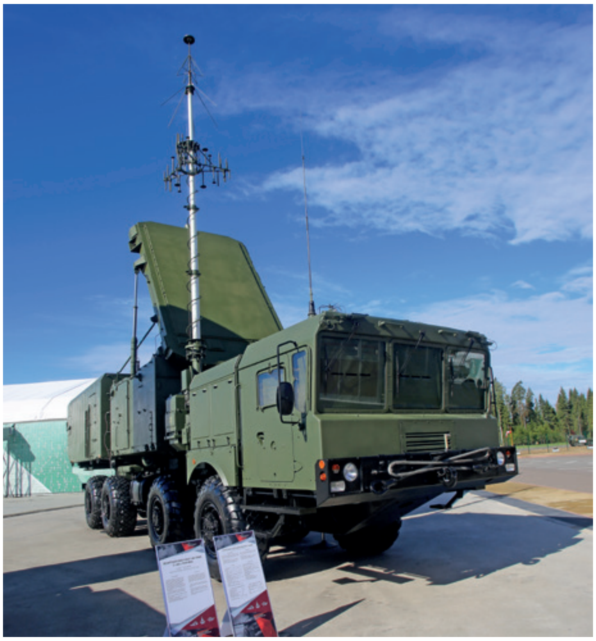
2. S-400E Triumf, S-400 Füze Savunma Alay Komutanlığı, Mürted (Akıncı) Base, Turkey. Turkey signed a $2.5 billion contract with Russia in late 2017 for the S-400, including 36 TELs. Deliveries began in July 2019. This is one of the Turkish 51P6E TELs, based on the Volat MZKT-7930 Astrolog chassis. These were delivered in standard Russian camouflage green.

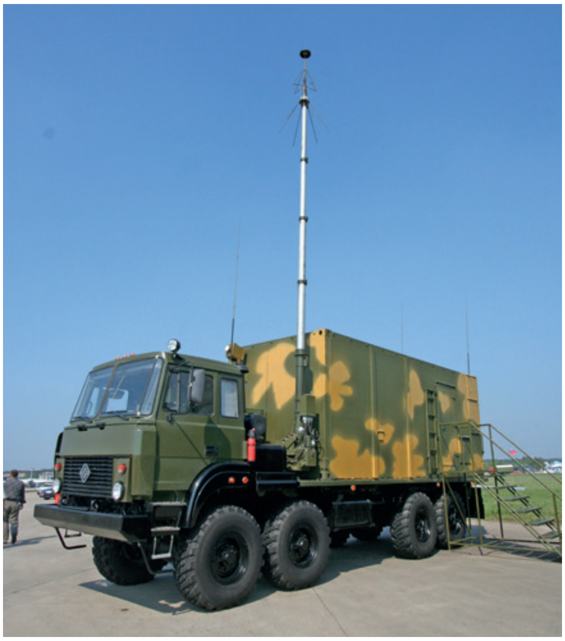
1



2







ABOVE LEFT
The 92N6A (Grave Stone) is the engagement radar for the S-400 Triumf system. It is mounted on an MZKT-7930 8x8 truck instead of the MAZ-543M so commonly seen on earlier versions of the S-300P radar vehicles.

ABOVE RIGHT
The 55K6 was the standard battalion command post for the S-300PMU-1 and its subsequent evolutions including the S-400 Triumf.

S-400 to intercept various Israeli attacks, it is not clear that this is due to technical shortcomings but rather due to secret Israeli-Russian agreements.

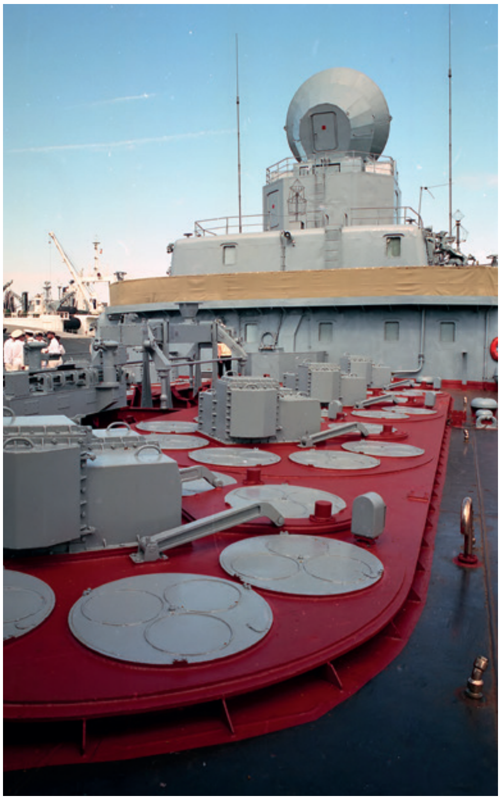
China again became the lead export customer for the S-400E, signing a contract in 2014 for six or more battalions. The first regimental set of S-400E equipment arrived in China in April 2018. China's regional rival, India, had discussed acquiring the S-300P system for more than a decade. In December 2015, the Indian Ministry of Defense approved a plan to acquire five S-400 Triumf regiments at a cost of $5.5 billion and signed a contract in 2018. Deliveries began in November 2021.

The most controversial sale of the S-400E system involved Turkey. The Turkish government started a program in 2005 to replace its old I-Hawk missile system with a new high-altitude system. Contenders included the US Patriot, Israeli Arrow, French Aster/SAMP-T, Chinese HQ-9, and the Russian S-300P or S-300V. There was sticker shock in Ankara over the high cost of many of these systems and it went into limbo for several years. In 2013, Turkish officials began to hint that the Chinese HQ-9/FT-2000 was favored, largely due to low cost and an attractive technology transfer offer. This led to considerable consternation within NATO since the system was not compatible with NATO air defense infrastructure. Turkey backed off an actual contract, reputedly over technology transfer and joint production issues.

In 2017, Turkey decided to acquire the Russian S-400E Triumf system in spite of US warnings. At the time, Turkey was a partner in the F-35 stealth fighter program, with a significant manufacturing share as well as a commitment to buy the aircraft. The US Department of Defense was concerned that Russian technicians supporting the S-400 system in Turkey could learn of the system's interactions with the F-35 stealth features. Turkey signed a $2.5 billion contract in late 2017 with Russia for the S-400, including 36 TELs. Turkey began receiving components of the S-400 in July 2019. As a result, the US suspended Turkey from the F-35 program. Turkey began taking delivery of the S-400 in the summer of 2019, and the first unit

OPPOSITE
The most significant difference between the naval S-300F and the land-based S-300P was in the fire control system. The S-300F Fort used the 3R41 Volna (Top Dome) as its engagement radar as seen here on the Slava-class cruiser *Marshal Ustinov* during a port call visit to Norfolk in 1989.

was deployed to Mürted AFB in December 2019. The Turkish purchase included both the large 48N6 and small 9M96 missiles.



The S-300F Fort missile system was contained in below-deck revolver launchers as seen above on the Slava-class cruiser *Marshal Ustinov*. This is the deck view of one of the aft B-204 (3S41) launcher arrays with the 3R41 Volna (Top Dome) engagement radar evident behind it.

The Naval S-300F Fort/Rif (SA-N-6 Grumble)

The S-300F Fort system was the naval offshoot of the S-300P. It was developed starting in 1969 to replace the older 4K65 Shtorm (SA-N-3 Goblet) system used on Soviet anti-air warfare cruisers. Although the S-300F uses the same missiles as the S-300P, the rest of its infrastructure is fundamentally different due to the nature of shipboard SAM systems. The program was led by chief designer, V. A. Bukatov of the NPO Altair, the primary Soviet institute for shipboard missile integration. Altair had already been working on a series of studies of long-range SAM systems including new vertical launchers developed by the Bolshevik plant in Leningrad under its Kvant program. The Project 1134B cruiser Azov was converted into the trials ship for the Fort developmental system in 1977. The industry and state trials lasted six years until 1983 with the system being accepted for service in 1984.

Due to the size and weight of the Fort system, only two cruiser classes were armed with the S-300F. The four ships of the Project 1144 Orlan (Kirov) class were armed with 96 5V55R missiles mounted in 12 B-203A, eight-cell, vertical-launch modules. The four cruisers of the Project 1164 Atlant (Slava) class were armed with 64 missiles in eight B-204 (3S41), eight-cell, vertical-revolver launchers.

The S-300F Fort system was integrated into the warship's air defense command-and-control network via the 5E26 fire control system, with the ship's early warning radars being used to cue the system. The engagement radar for this system was the 3R41 Volna (Top Dome). The Fort-M introduced the newer 48N6 missiles from the land-based S-300PM family. One ship of the Orlan class, the Yuri Andropov (later Pyotr Velikiy), was equipped with the full configuration, including the new 5E40 fire control system. In this case, one of the usual two 3R41 Volna engagement radars was replaced by a navalized version of the 30N6 (Tomb Stone) radar.

The export versions of the S-300F were codenamed Rif and Rif-M, the latter corresponding to the Fort-M. Two Rif-M systems were ordered by China in 2002 and delivered in 2005 for the new Type 51C destroyers. The Chinese warships use a navalized 30N6E radar.

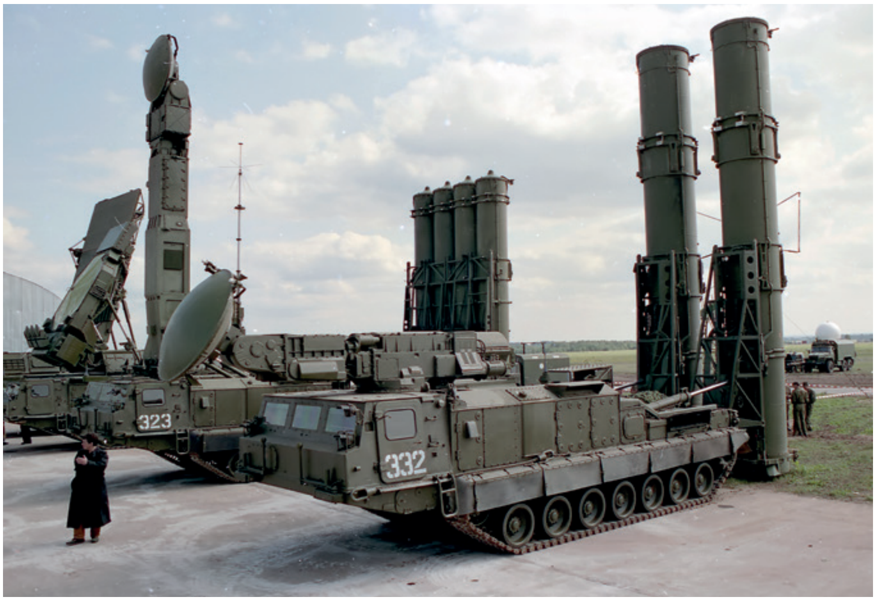
One of the more curious aspects of the Fort program was a proposal by Almaz to deploy a land-based version of the Fort system for defense of key naval bases. The Volna radar station would have been mounted on a concrete platform and the revolver launchers in an underground stand. It is not clear whether the Soviet navy ever took this proposal seriously. In the event, key Soviet naval bases were defended by the usual S-300P systems.

The key designers behind the S-300V were Veniamin P. Yefremov of the Antey design bureau on the left and Lev V. Lyulev of the Novator design bureau on the right.

S-300V (SA-12 Giant/Gladiator)

The army's PVO-SV was interested in the development of an air defense system capable of defeating nuclear-armed TBMs since the late 1950s. This was due to the rapid increase in the number of NATO TBMs including the US Army's Honest John and Corporal, and the French Pluton. In the early 1960s, the Zashchita (Defense) program examined whether it would be possible to develop a multi-role SAM based on the existing Krug (SA-4 Ganef) that would be capable of defeating both aircraft and TBMs. However, the advent of newer US Army missiles led to the replacement of this effort with more advanced projects. A major development program began in 1965 under the codename Prizma (Prism) at NIEMI near Moscow. This bureau led the previous Krug missile program and became better known as Antey in 1983. Prizma outlined a "universal" system based on a pair of missiles, one capable of intercepting aircraft and a second type, capable of defeating both aircraft and TBMs. The system was designed for cross-country mobility using tracked vehicles.

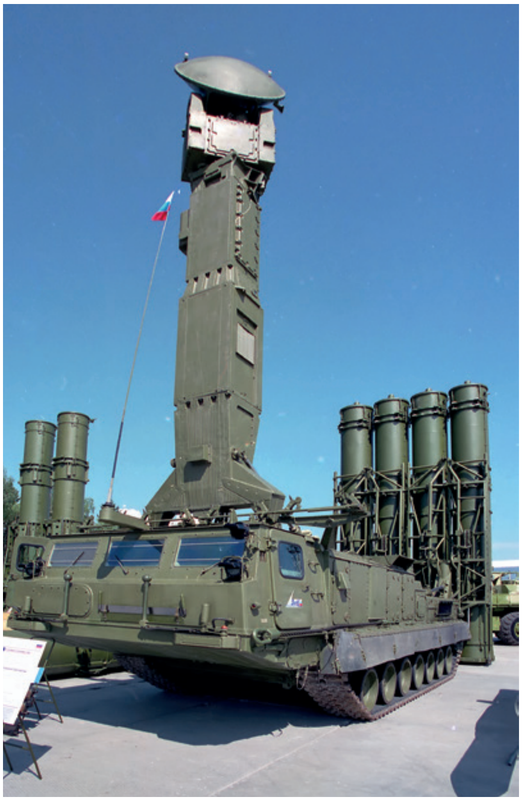
Prizma was declared to be unrealistic by Grigory V. Kisunko, who at the time was the head of Program A. This was the primary Soviet effort to field a nuclear-armed anti-ballistic missile system for the defense of Moscow against intercontinental ballistic missiles. Kisunko's skepticism was due to ongoing development work on the S-225 program. The S-225 was a complementary air defense missile system to Program A aimed at combating intermediate-range ballistic missiles. This program made it clear how difficult this technological problem was for a fixed site system, and so Kisunko was skeptical of trying to accomplish the anti-ballistic missile mission with a more challenging mobile



The S-300V system uses two different TELARS, the 9A82 in the foreground, armed with the two 9M82 missiles, and the 9A83-1 behind it, armed with four 9M83 missiles.

system. In spite of this, Prizma was supported by several influential military and industry leaders. By 1968, the program was led by the new chief designer of NIEMI (Antey), V. P. Yefremov.

Before Prizma won government approval to transition to full-scale engineering development, the controversy over the "universal" S-500U program broke out as mentioned earlier. Yefremov was one of the principal opponents of S-500U, realizing that the system was not configured for the anti-TBM mission and that government approval of S-500U would doom Prizma. In the event, S-500U was dropped in favor of the trio of S-300 programs. The army's S-300V program was given the green light by the Kremlin on May 27, 1969, absorbing the previous Prizma studies.


The 9A83-1 TELAR of the S-300V system features a folding illumination radar at the front of the vehicle which serves as a command link to the missile during the engagement.

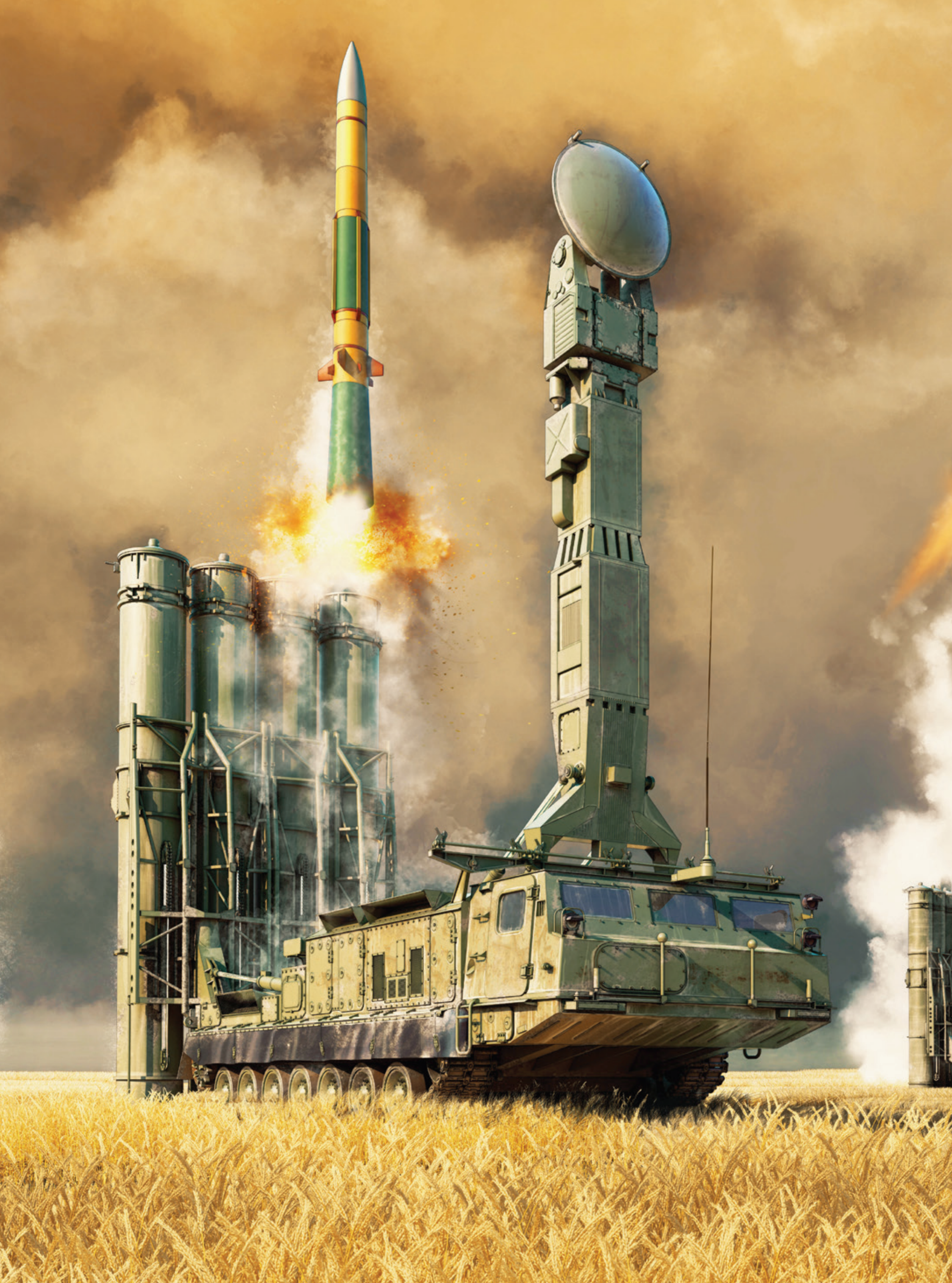
Unlike tactical air defense systems such as the Kub (SA-6) and Osa (SA-8) that were used to defend tank and motor-rifle divisions, the mission of the S-300V was to defend high-level formations such as fronts against ballistic missile attack. The design requirements specifically identified the threat as ballistic missiles such as Lance and Pershing-1 as well as aero-ballistic missiles such as SRAM. A secondary mission was to deal with surveillance aircraft such as the E-3 Sentry AWACS as well as stand-off electronic warfare aircraft such as the EF-111. The program was led by Antey while the missile development was undertaken by the Novator design bureau in Sverdlovsk under L. V. Lyulev. The system's Obzor-3 radar was developed by the NIIIP (Scientific Research Institute of Precision Measurement) in Novosibirsk while the Imbir radar was developed by a department within Antey.

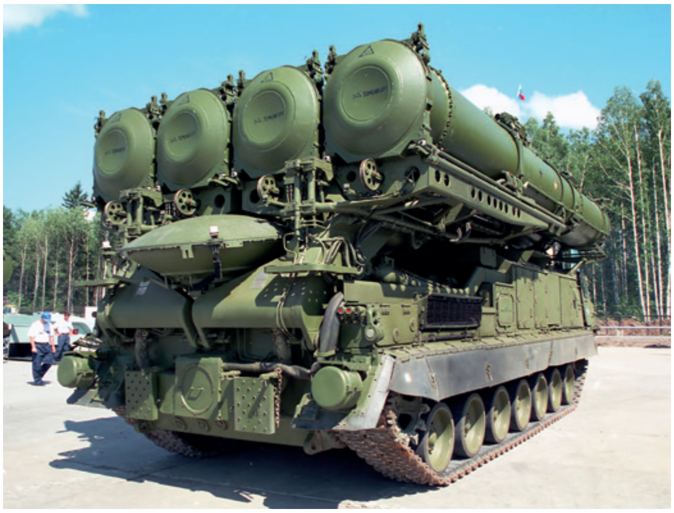
From the outset, the development approach was to break the mission into two sequential stages. The lesser technological challenge was to defeat short-range ballistic missiles such as Lance as well as aircraft. The greater technological challenge was to defeat medium-range ballistic missiles such as Pershing-1. The terminal velocity of a ballistic missile is dependent on its range. A long-range missile will have a greater terminal velocity than a short-range system. High terminal velocity was a challenge for two reasons. To begin with, a faster ballistic missile was simply more difficult to track and intercept. Secondly, the faster the terminal velocity, the shorter the reaction time of the anti-missile system. As a result, initial work focused on the short-

D

S-300V1 LAUNCH

The S-300V1 system is designed for fully mobile operation and does not require any prepared basing. On the left, a 9A83 missile has exited the TPK canister on a 9P83 TELAR. Unlike the cold-launch gas generator on the S-300P system, the 9D139 gas generator on the S-300V is a hot-gas system with a momentary flash when the missile exits the launch canister. The missile then coasts about 20–30m above the launch canister at which point the first-stage 9D136 booster rocket motor ignites. Prior to launch, the missile is pre-programmed on its initial flight path, and once the booster motor ignites, the missile flight control system orients the missile into the proper flight path by steering gas-dynamic thrusters within the booster motor. This can be seen with the missile launch to the right where the missile is beginning its flight trajectory to target. To the right is the 9S32 Grill Pan engagement radar vehicle.





A 9A83-1 TELAR in transport mode with the radar and launchers folded down. The radar folds toward the rear, and the antenna dish can be seen protruding under the missile transport-launch containers.

range targets since it was felt that once that this mission was mastered, the more-challenging long-range mission would have a greater chance of success.

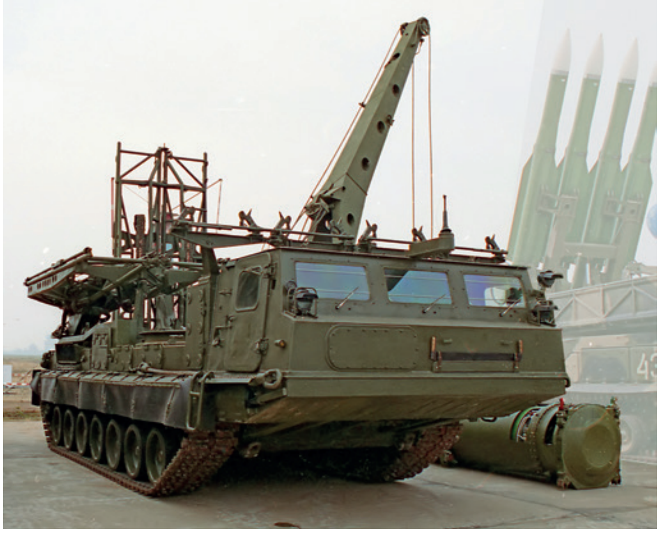
S-300V was nominally expected to share technology with the other S-300 programs, especially S-300P. Fakel offered a version of its V-500 missile series, the V-500V, for the antiaircraft requirement of S-300V. This was rejected by the Antey designers. Antey decided to focus its attention on the anti-missile aspects of the mission since a missile capable of intercepting another missile would certainly be capable of engaging aircraft.

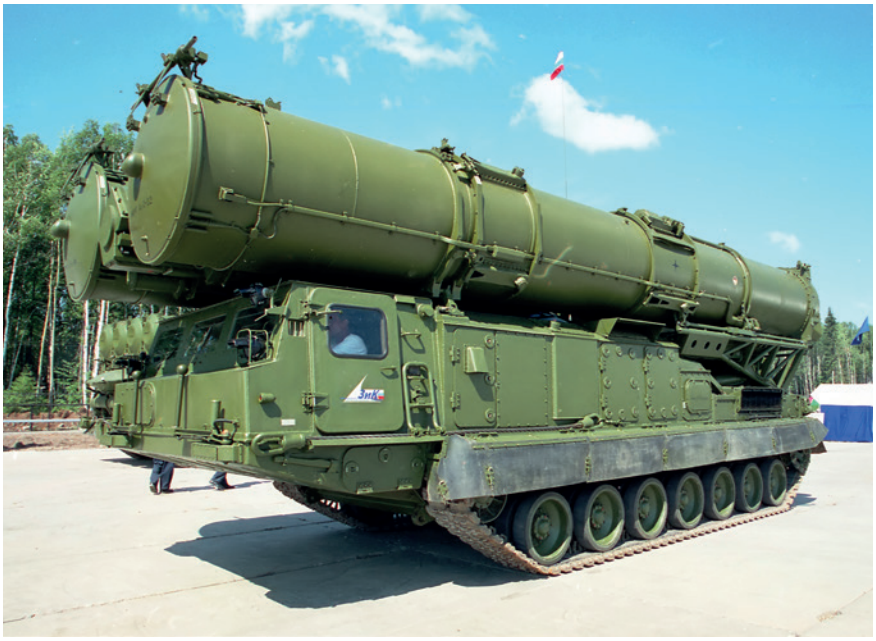
Chief designer L. V. Lyulev at the Novator bureau had already been working on the 5Ya26 anti-ballistic missile for the S-225 ABM program. This research formed the basis for the new KS-96 missile family for the S-300V system. The KS-96 was a pair of similar missiles using a conical two-stage design powered by solid rocket motors. The smaller 9M83 and larger 9M82 shared a nearly identical upper stage and differed primarily in the size and thrust of the first stage. The missiles were delivered in TPKs that included a gas generator at the base to eject the missile from the tube.

The challenge of developing this missile was due to the extremely high speeds necessary and the resultant problems of high G-loads and extreme heating of the airframe in this hypersonic regime. On the 9M83 missile, the first-stage 9D140 engine was steered using gas-dynamic thrust-vector controls within the exhaust chamber during its five-second burn. As the first stage burned out, the second stage was explosively separated and the 9D126 sustainer motor ignited for 14 seconds and maneuvered the missile using a set of aerodynamic fins. The peak speed of the 9A83 missile was Mach 5 (1,700m/s; 6,120km/h; 3,800mph). The intention was to intercept the incoming missile at an altitude of no less than 13km since, at this altitude, any nuclear detonation would have little effect below. The 9E49 semi-active radar homing system was used in the last ten seconds of the terminal intercept phase. The missile could also be command-guided by the engagement radar. The 9N127, 150kg high-explosive-fragmentation warhead was detonated using a radio proximity fuze. It was configured to aim a narrow stream of metal fragments at the target by rotating the missile. The missiles were manufactured by the Kalinin Plant No. 8 in Sverdlovsk (now Yekaterinburg) that was also home of the Novator design bureau.

The vehicles of the S-300V system used the Obiekt 830 family of tracked

The 9A85 transloader vehicle is used to support the 9A83 TELAR. The crane in the center of the vehicle bed is used to transfer missile transport-launch canisters to the missile rack of the 9A83 TELAR.





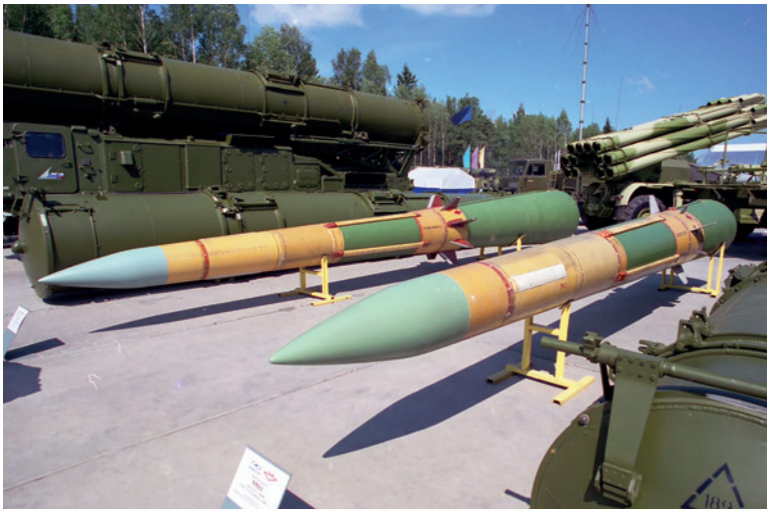
The 9A82 TELAR carries only two 9M82 missiles due to their larger size. It is seen here in travel mode with the illumination radar and missile containers folded.

vehicles based on the 2S7 Pion 203mm self-propelled gun and developed by the Kirovskiy plant in Leningrad (now St. Petersburg). The missile launch system was developed in Sverdlovsk by the Start design bureau under A. I. Yaskin, co-located at the same plant as Lyulev's Novator missile design team. For the initial 9M83 missile (SA-12A Gladiator), the basic TELAR (transporter-erector-launcher and radar) was the 9A83. This vehicle carried four missile launch canisters. The 9A83 was fitted with a mast-mounted, traversable, high-gain antenna used to transmit mid-course guidance commands to the missiles and provide continuous wave illumination of the target for the missiles' semi-active radar seekers during the interception phase. The 9A83 was accompanied by the similar 9A85 transloader-launcher vehicle. This vehicle carried four missile containers but lacked the command antenna. Instead, it had a crane on the rear bed that could be used to transfer the missiles to the TELAR. The 9A85 transloader could erect and launch missiles under the control of the neighboring 9A83 vehicle.

The basic S-300V1 launch battalion was directed by a 9S457 mobile command post and a 9S32 (Grill Pan) engagement radar. This radar could track up to 12 targets and control up to six missiles simultaneously. It had an effective target acquisition range of 240km against a fighter, 140km against a Pershing-1 missile, and about 95km against the Lance missile.

The 9S457 command post was a large shelter containing the battalion's communication and data processing modules. This command post received data from the brigade's early warning radars which it then passed on to the 9S32 radar vehicle to initiate tracking the targets. The command post also selected the targets based on data from the 9S32 sector radar, and then directed the battalion's launch vehicles to engage the targets. The data displays in the command post could handle the acquisition of 200 targets, initiate tracking on up to 48 targets, and designate 24 of these targets to the battalion 9S32 Grill Pan engagement radars.

Testing of the initial S-300V1 system began at the GNIIP-11 proving



The two missiles of the S-300V system are the smaller 9M83 (Gladiator) missile in the foreground and the larger 9M82 (Giant) missile behind it. Both missiles share a nearly identical second stage, but the 9M82 missile has a substantially larger first stage due to its larger booster motor.

ground at Emba near Lake Balkash in 1975. There were significant problems with the early system leading to extensive redesign of the missiles, launch systems, and command-and-control network. The state trials of the system were undertaken in 1980–81. The baseline S-300V1 system was accepted for Soviet army service in 1983. The first training unit was established at the OVZRU school in Orenburg in early 1984, followed by initial unit training at Emba in 1985. Production of the 9M8 Krug-M (SA-4 Ganef) ended at Sverdlovsk in 1982 in anticipation of the serial production of 9A83 missiles. Full-scale production of the missile did not begin until 1985. The first two S-300V brigades were deployed in the Kiev and Carpathian Military Districts in the mid-1980s. The third brigade was deployed near Pskov in the early 1990s.

Tracked vehicles of S-300V system

Designation	Role	Vehicle chassis
9A82	TELAR for 9M82 missile	Obiekt 830*
9A83	TELAR for 9M83 missile	Obiekt 831
9S15M Obzor 3	Surveillance radar	Obiekt 832
9S32	Battery engagement radar	Obiekt 833
9A84	Transloader for 9M82 missile	Obiekt 834
9A85	Transloader for 9M83 missile	Obiekt 835
9S19M2 Imbir	Surveillance radar	Obiekt 836
9S457	Command post	Obiekt 837

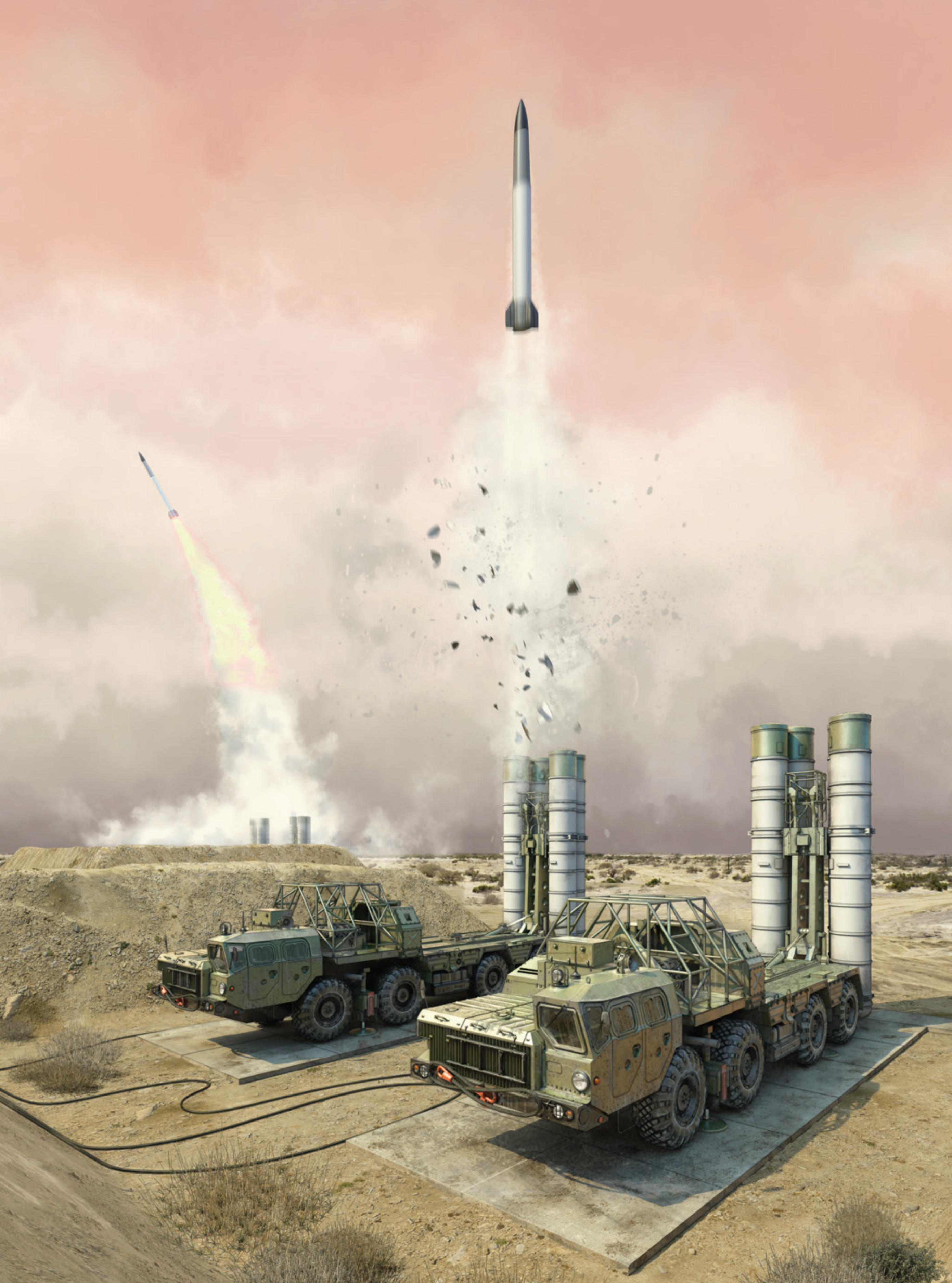
*These vehicles are sometimes referred to with a GM prefix (*Gusenichnaya machina*: tracked vehicle) instead of Obiekt, e.g. GM-830

E

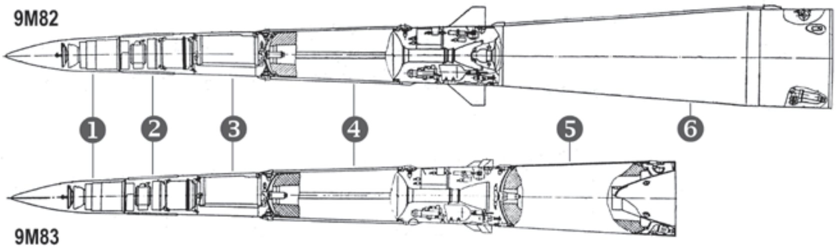
S-300PM LAUNCH POSITION

The S-300PM battalion can vary in size, and usually includes 8–12 5P85S TELs. Although the system is mobile, launch battalions are generally deployed in standard fixed sites with the TELs located within protective earthen berms. The site includes separate positions for engagement radar, surveillance radar, and supporting elements. The berms are rectangular in shape, about 4m high, shielded on three sides and with one side open to permit access. Concrete pads are often located inside the position with one per vehicle. The battalion is divided into launcher sections of four TELS each. In some cases, all four TELs are located within a single, large launch position. Another common deployment (as shown here) is for the launch section to be divided in two separate U-shaped positions with two TELs in each, roughly 20x35m in size.

The S-300PS system uses a cold-launch system to eject the 48N6 missile from the TPK canister, so there is no flash when the missile first leaves the tube. The missile coasts for about 15–20m before the rocket motor ignites. There are control vanes within the rocket exhaust chamber which begin to steer the missile to its proper flight path once the motor ignites, as can be seen with the launch in the background.



This cross-sectional drawing shows the layout of the 9M82 (Giant) and 9M83 (Gladiator) missiles including: 9E49 guidance section (1); flight controls (2); 9N127 warhead (3); 9D126 sustainer motor (4); 9D140 booster motor (5); and 9D128 booster motor (6).



The next stage of the development program centered around the larger 9M82 (SA-12B Giant) missile and its associated equipment, especially its dedicated radars such as the Imbir (High Screen). The primary difference between the larger 9M82 missile and the smaller 9M83 was its first stage with the larger and more powerful 9D128 solid-fuel rocket booster. As a result, it had a blistering maximum speed of Mach 9 (2,600m/s, 9,360km/h, 5,815mph).

The 9M82 missile was about double the weight of the 9M83: 4,685kg vs. 2,290kg. As a result, its 9A82 TELAR vehicle could carry only two missiles. The TELAR had a larger command antenna than on the 9A83, but it was mounted directly over the vehicle cab and lacked the elevating mast feature. It also had a dedicated transloader vehicle, the 9A84, that carried two missiles.

Test launches of the larger 9A82 missile began in the early 1980s at the Emba proving ground. Starting in June 1983, Temp (SS-12 Scaleboard) ballistic missiles were launched from Kabanbay west of the Aral sea toward Emba, serving as a surrogate target to mimic the Pershing missile for final testing.

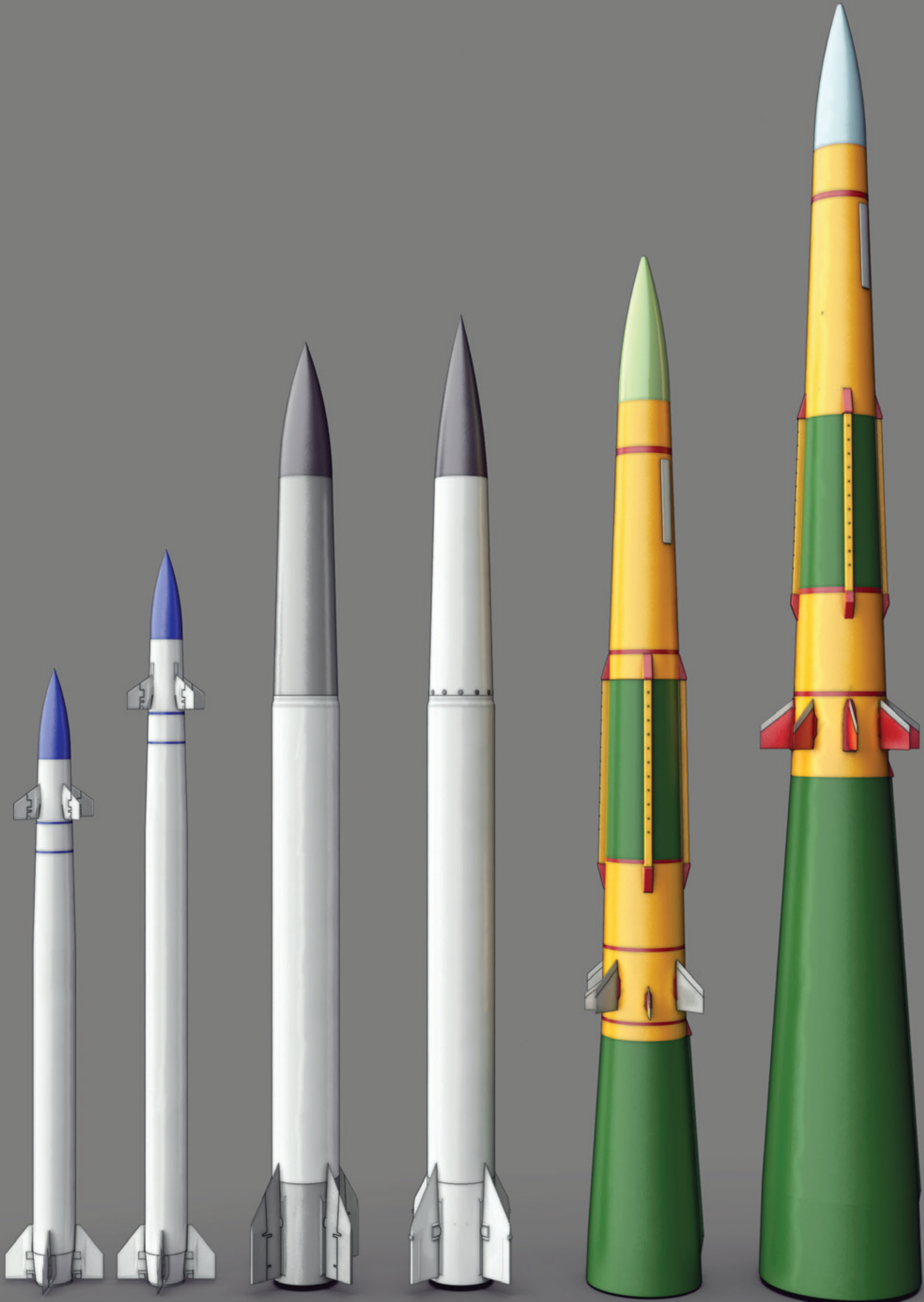
The full S-300V system tests including the 9M82 missile were conducted at Emba in 1985–86. As a result, the complete S-300V (9K81) system including both missile types was adopted for service in 1988. This system arrived at a point in which the Soviet defense budget was declining due to Mikhail Gorbachev's reforms. As a result, production of the new missile was slow and at a small scale. Ultimately, only six brigades were deployed since funding fell sharply after the collapse of the Soviet Union.

The S-300V was deployed as an air defense brigade at the front level in wartime and at military district level in peacetime. The brigade headquarters included the 9S52 Polyana-D4 command post vehicle, and a Pori-P2 radar processing center. The brigade's 9S15M Obzor-3 (Bill Board A) was a phased-array surveillance radar designed to track aircraft and short-range ballistic missiles out to about 250km and was capable of simultaneously tracking 200 targets. The 9S19M2 Imbir was a vehicle-mounted sector-search radar. It could track 16 targets simultaneously and was used primarily against ballistic missiles such as Pershing and aero-ballistic missiles such as the

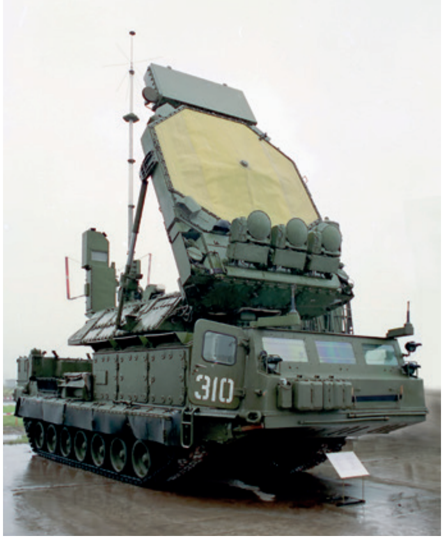
F

S-300 MISSILE GALLERY

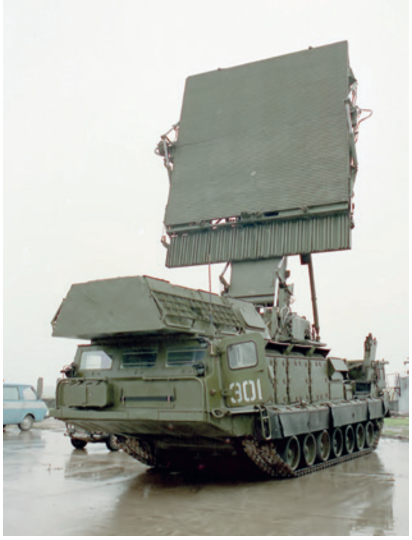
The missiles shown here (left to right) are the 9M96, 9M96D, 5V55R, 48N6, 9M83, and 9M82. The Fakel missiles are conventionally marked with the missiles painted largely in white, with gray dielectric nose cones covering their guidance systems. The Novator 9M83 and 9M82 are very different in finish. These have pale-green dielectric nose cones, but the missile bodies are covered with special heat-resistant coatings which give them a dramatically different appearance.



RIGHT
The 9S32-1 (Grill Pan) is the phased-array engagement radar for the S-300V system that tracks both the targets and missiles during the engagement.



FAR RIGHT
The 9S15M Obzor-3 (Bill Board A) is the surveillance radar for the S-300V battalion, detecting and tracking up to 200 targets.



AGM-69 SRAM. It was the final radar element of the system to be accepted for service due to the technical challenges of its design.

Brigade strength was usually two launch battalions. Some of the early battalions were equipped only with the initial 9M83 missiles and their associated 9A83 TELAR, and lacked some of the later equipment such as the Imbir radar. A standard battalion headquarters consisted of a 9S457 command post vehicle, a 9S15M Obzor-3 aviation tracking radar, and a 9S19M2 Imbir missile tracking radar. Each standard battalion had four fire units including a headquarters with 9S457 tracked command post; a 9S32 engagement radar; 2 9A82 TELAR with a single 9A84 transloader; and 4 9A83 TELAR with 2 9A85 transloaders. A fire unit had 55 tracked vehicles and about 20 trucks.

S-300VM (SA-23)

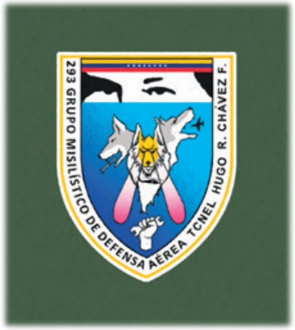
Development of the improved S-300VM (9K81M; SA-23) system began in the mid-1980s. The aim of this program was to incorporate lessons learned, introduce product improvements, and increase the system performance to deal with newer threats such as the Pershing-2 missile. The S-300V2 was a block upgrade with improved anti-missile acquisition by using a pair of 9S19M2 Imbir radars at battalion level instead of one of the 9S15M Obzor radars. The S-300V3 used the improved 9M82M and 9M83M missiles with testing beginning at Emba in 1989. The new missiles had faster reaction time, a higher terminal speed, and improved kill probability, estimated at

G

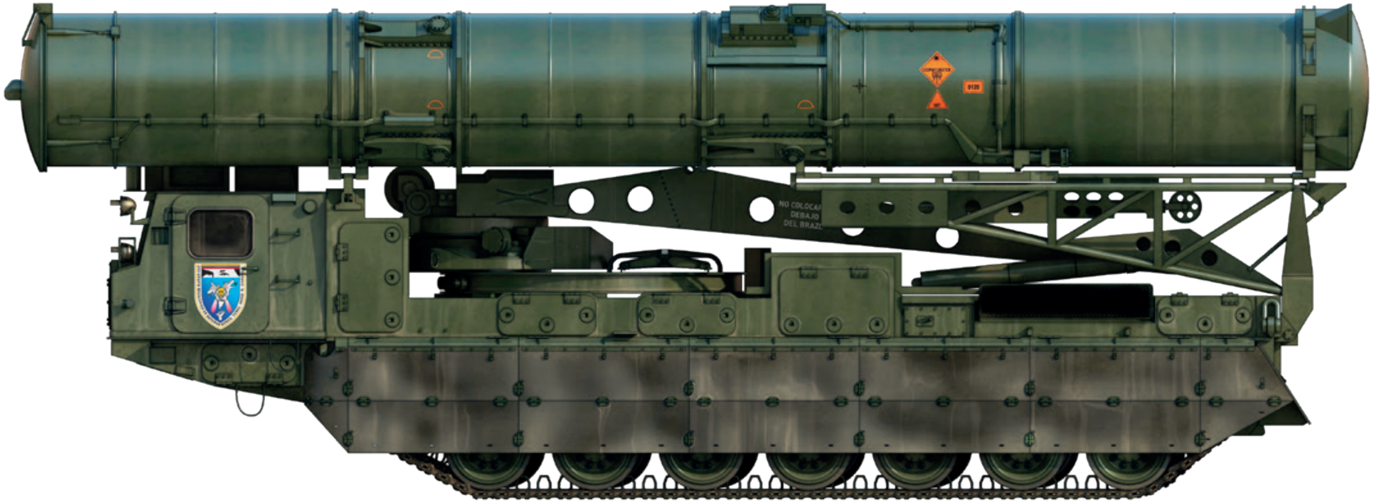
ANTEY-2500 EXPORTS

1. 9A82ME, Venezuelan 293° Grupo Misilístico de Defensa Antiaérea Comandante Supremo Teniente Coronel Hugo Chávez Frias, 29ª Brigada de Defensa Aérea de la Región de Defensa Integral Los Llanos. The Venezuelan Antey-2500 systems were delivered in the usual Russian camouflage green. Many of the unit's vehicles are painted with the unit emblem shown here in the inset. Some of the TELAR vehicles were fitted with an unusually deep side skirt.

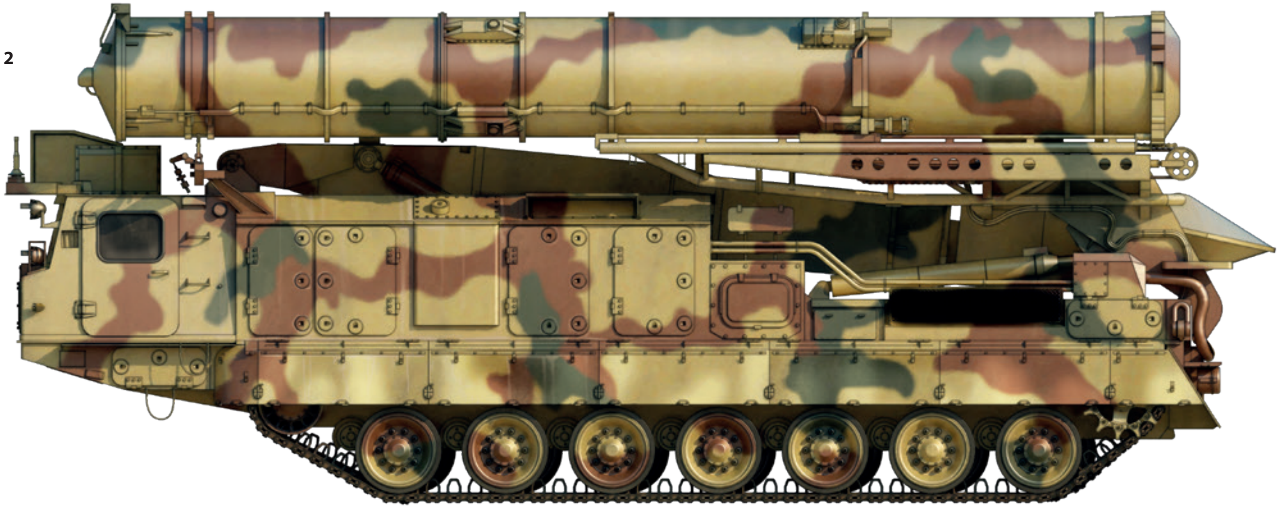
2. 9A83ME, Egyptian Air Defense Command, 2017. The vehicles of the Egyptian Antey-2500 system were delivered in a particularly vivid sand-yellow color. Some of the vehicles, including many of the launchers, also had a camouflage pattern of dark green and brown applied over this.

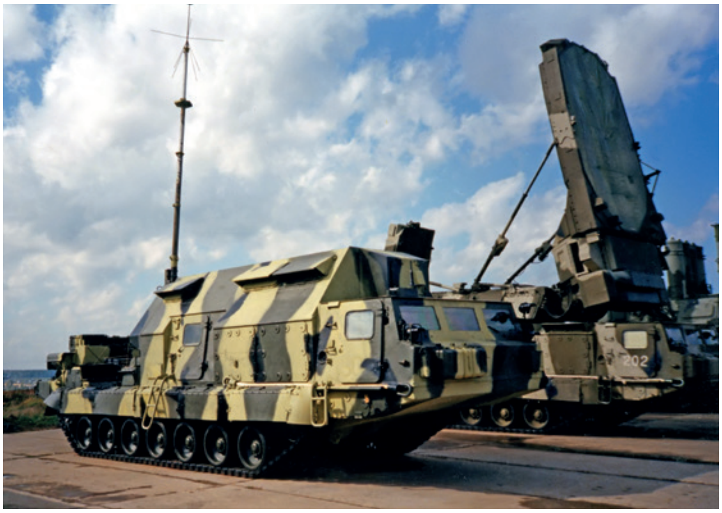

293 GRUPO MISILÍSTICO DE DEFENSA AÉREA TCNEL HUGO R. CHÁVEZ F.

1


NO COLOCA
DEBAJO
DEL BRAZ
0120

2



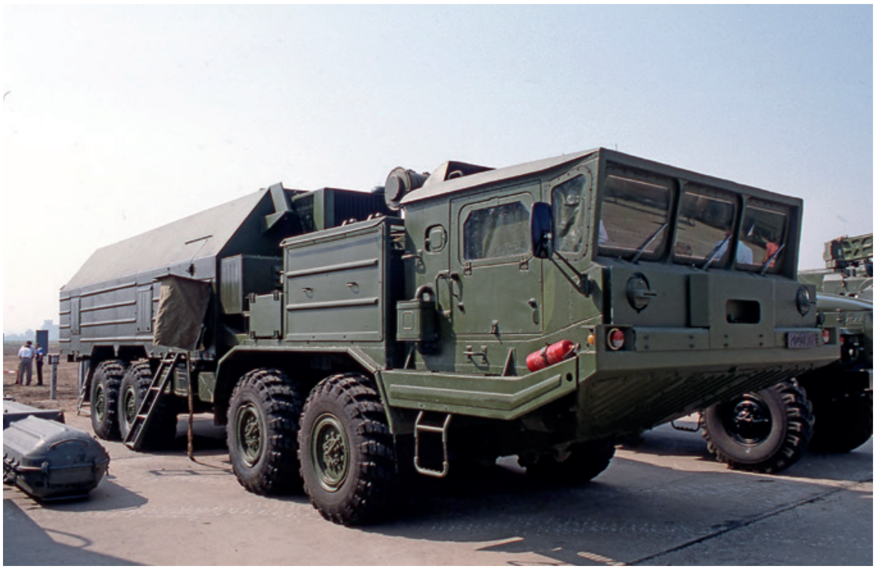


The 9S457 command post vehicle of the S-300V battalion with a 9S12M2 Imbir (High Screen) surveillance radar vehicle behind it.

95 percent vs. 40–70 percent for the initial versions of the missiles. The system introduced improvements in the radars and missiles that extended the effective envelope of the system from 100km to 200km in the case of aircraft, and the maximum altitude against ballistic missiles from 25km to 30km. Also, the upgraded system could engage targets such as the Pershing-2 with speeds of 4,500m/s compared to 3,000m/s in the earlier versions. It also introduced the 9M82MD missile that extended the range from the 200km of the baseline missile to 450km to defeat stand-off sensor aircraft such as the E-3A AWACS or EF-111. The effective range of the earlier types was limited due to a short operating time of the on-board power supply which was significantly improved on the 9M82MD. The improved S-300V3 system was accepted for service in 1996 and five battalions were deployed with the upgraded S-50M system around Moscow.

Continued upgrades to the system led to the S-300V4, described by Antey as a "deep modernization." This included the upgraded 9A83M TELAR and 9A84M transloader. The redesigned 9S32M (Grill Screen) took over the functions of both the earlier 9S32 as well as the 9S19 Imbir. The S-300V4 was accepted for the Russian Army units in 2011 with an initial upgrade of three battalions in 2015.

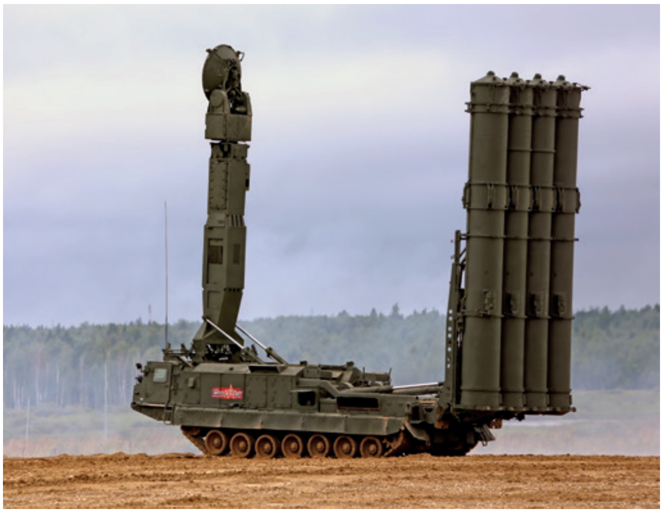
Antey began attempts to export the S-300VM in the early 1990s but had little initial success due to the cost and complexity of the system. Due to confusion between the S-300V and S-300P among export clients, in the late 1990s Antey began referring to the S-300VM as the Antey-300V, and later



The 9S52 Polyana-D4 mobile command post on the BAZ-6950 truck was used in the headquarters of the S-300V air defense brigade to automate data handling from the brigade radars and to pass targeting information to lower commands.

as Antey-2500. The 2500 referred to the ability of the system to deal with ballistic missiles with ranges of up to 2,500km. This was purely a marketing move and did not refer to a new system.

There have been two export clients for the Antey-2500. Venezuela ordered two battalions that were deployed at Base Aérea Militar Capitán Manuel Ríos starting in 2012. Egypt ordered the Antey-2500 in 2014, comprising four launch battalions and associated equipment. Egyptian troops began training on the system in 2015 and it was fully deployed by 2017.



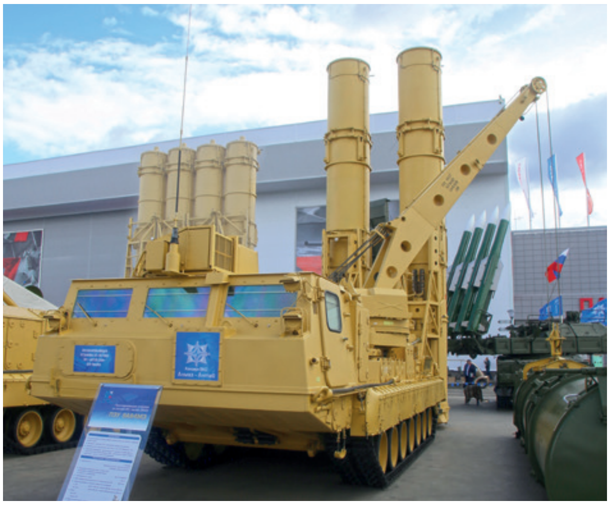
A 9A83M TELAR of the S-300V4 system on display at the Alabino proving ground outside Moscow in 2017. It is in launch configuration with the forward illumination antenna raised as well as the four missile transport-launch containers.

S-500 Prometey ATBM

At the turn of the new century, Almaz-Antey began work to rejuvenate the S-300V for export market. The use of the tracked vehicles in the system was regarded as unnecessarily expensive and complex. The experimental S-300VMK (K: *kolesniy*: wheeled) shifted the S-300VM equipment from tracked vehicles to heavy trucks. This resulted in the 98N6 Abakan system, that included the new 51P6 TELAR on the BAZ-6909.60 10x10 truck. This launcher carries a pair of the long-range 9M82MD missiles. The system also included a new surveillance radar, the 98L6A Yenisey. The Abakan was first unveiled in 2020.

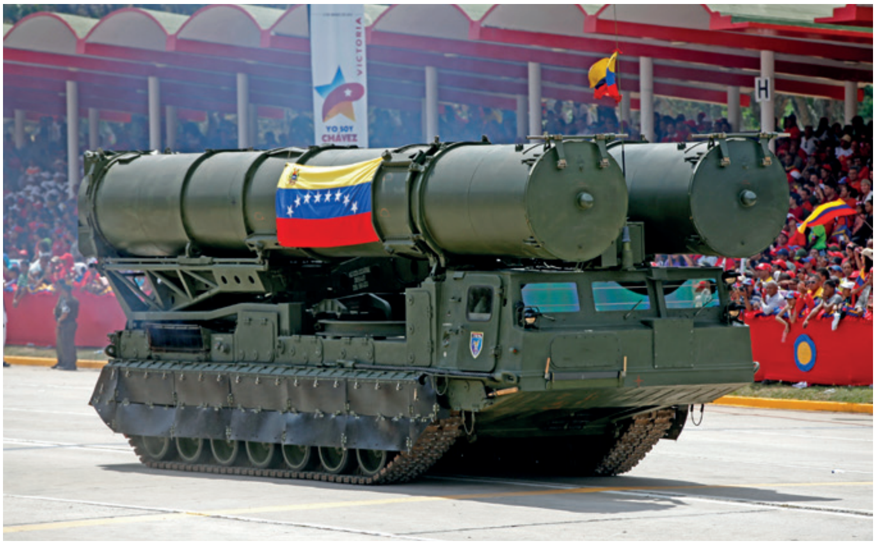
A broader effort to modernize the S-300V started in 2002 under the codename Vlastelin (Overlord) and later as Triumfator. In some respects, this was a renewal of the S-500U of 1968, aiming to deploy a universal system with the best features of the S-300P and S-300V but in modernized form. The program re-used the S-500 designation and was eventually codenamed Prometey (Prometheus). The missiles at the heart of the system were the Fakel 40N6 from the S-400 program and two new hypersonic missiles for the interception of ballistic missiles, the Novator 77N6 and 77N6-1. These are comparable to the 9M82 and 9M83, differing in size and range. They are intended primarily for engaging ballistic missiles in the atmosphere and near the edge of space. They increased the range of the system from 400km on the S-300V4 to 600km on the Prometey. These new missiles underwent initial flight tests in late June 2014. The plan had been to introduce the system into service in 2016, but this was delayed until 2021.

The S-500's 55P6 TELAR is based on the BAZ-6909.60 heavy truck while the 51P6M is based on the MZKT-7930 truck. There are two different engagement radars for the system, the 76T6 and 77T6 X-band phased-array radars, presumably associated with the different missiles/TELARs. The various radar



A 9A84ME transloader of the Antey-2500 system that supports the 9A82ME TELAR. This clearly shows the crane mounted on the rear bed of the vehicle for transferring missile transport-launch canisters onto the launch rails. This vehicle is in the export delivery scheme for Egypt.

A 9A84ME transloader of the Venezuelan 293° Grupo Misilístico de Defensa Antiaérea Comandante Supremo Teniente Coronel Hugo Chávez Frias on parade in Caracas on March 5, 2014 in honor of Chávez. (WikiMedia Commons CC-BY-SA-2.0)



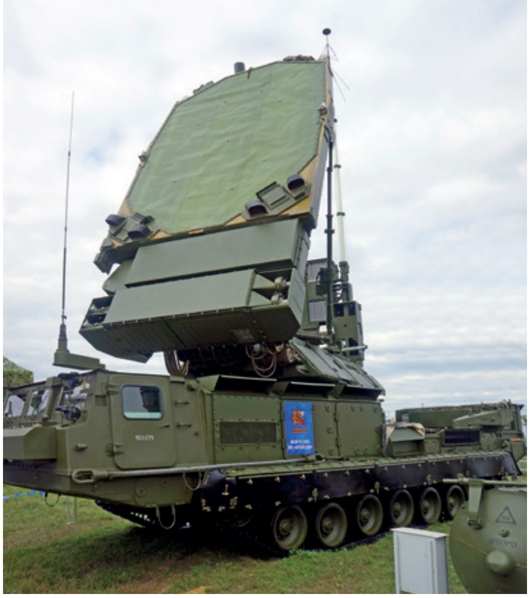
and command vehicles are also truck based rather than on tracked vehicles. The first S-500 Prometey battalion was delivered in October 2021 to the 15th Special Mission Aerospace Army, covering Moscow and the Central Region of Russia.

ASSESSMENT

The S-300P is often compared to the US Army's MIM-104 Patriot that entered service in 1984. The two systems are technologically similar, both employing TVM guidance and using phased-array radars. However, they are substantially different in mission. The S-300P was developed as a strategic system for defense of national infrastructure such as cities and military bases. In contrast, the Patriot was a tactical air defense system designed to defend army units from air attack. The Patriot system has significantly smaller missiles. The basic MIM-104A PAC-1 missile weighed 900kg with a 90kg warhead compared to the 1,665kg of the 5V55R with a 130kg warhead. Both missiles had a range of about 70km. The developmental trends in both systems were quite different. The S-300P moved in the direction of longer range. In contrast, the later versions of the Patriot missiles such as the PAC-2 and PAC-3 were developed to deal with ballistic missiles and had shorter range than the initial antiaircraft types.

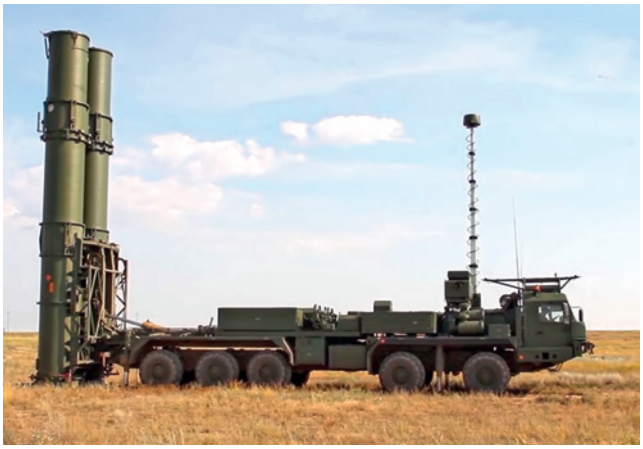
When introduced to service in the late 1980s, the S-300V offered anti-missile capabilities unmatched by any system in NATO at the time. The only comparable system is the US Army's THAAD that entered service two decades later in 2008. Although both systems are intended for anti-missile defense, they are a generation apart in design. The THAAD's

The new 9S32M (Grill Screen) engagement radar of the S-300V4 system. The upgraded configuration of the auxiliary antennas below the main phased-array differs considerably from the earlier 9S32 radar.



missile is significantly smaller, weighing only 900kg compared to 2,290/4,685kg for the 9M83/9M82 missiles. The weight difference is due to a completely different configuration. The THAAD is a single-stage missile and lacks a warhead since it is designed to directly collide with an incoming ballistic missile re-entry vehicle. In addition, it uses an imaging infra-red seeker for terminal guidance rather than semi-active radar guidance. Like the 9M82 (Giant), the THAAD has a top speed of about Mach 9 (2,800m/s).

How effective are the S-300 missile systems? It is very difficult to make such an assessment as there have been very few combat engagements by the S-300P and none by the S-300V. Performance of these complicated systems is dependent not only on their basic technical features, but on the complex interactions of the launchers, missiles, radars, and fire control sub-systems. As was evident in the failure of Syrian S-300P systems to thwart Israeli air attacks in 2020–21, the quality of crew training, as well as the tactics and capabilities of the opposing air force, are as important as the system's paper statistics.



The 55P6 TEL of the S-500 Prometey is based on the BAZ-6909.60 heavy truck. It is armed with two 77N6 missiles and entered Russian service in 2021.

FURTHER READING

Biedermann, Bernd, et al., *Der Fla-Raketenkomplex S-300PMU in der NVA*, Steffen Verlag, Friedland, 2012

Ganin, S. et al., *Raketniye kompleksy PVO-Strany*, Aviatsiya i Kosmonavtika, December 2002

Korovin, V. N. *Rakety Fakela*, MKB Fakel, Moscow, 2003

Korovin, V. N. et al., *Ot Berkuta do Pyatsotki: Traektoriya liderstva*, TsVPI MGIMO, Moscow, 2020

Korovin, V. N. et al., *Petr Grushin*, Politekhnika Izd., St. Petersburg, 2011

Lenskiy, A. G. and M. M. Tsybin, *Sovetskiy Voiska PVO v poslednie gody Soyuza CCR: Spravochnik. Chast I (2013), II (2014), III (2015)*, Info-Ol, St. Petersburg, 2013–14

Muratov, Mikhail, *Zenitnye raketnye kompleksy PVO Sukhotputnikh voysk*, Tekhnika i Vooruzhenie, Moscow, 2003

Pervov, Mikhail, *Sistemy raketno-kosmicheskoy oborony Rossii sozdavalis tak*, Aviarus-XXI, Moscow, 2003

Pervov, Mikhail, *Zenitnoe raketnoe oruzhie PVO-Strany*, Aviarus-XXI, Moscow, 2001

Petukov, S. I. and I. V. Shestov, *Istoriya sozdaniya i razvitiya vooruzheniya i voennoy tekhniki PVO Sukhoputnykh voysk Rossii*, Russian Academy of Missile and Artillery Science, Moscow, 1997

Shirokorad, Aleksandr, *Rakety nad morem: Raketnaya tekhnika otechestvennogo voenno-morskogo flota*, Tekhnika i Vooruzhenie, Moscow, 1997

Spasskiy, Nikolai, et al., *Russia's Arms Catalog: Volume V: Air Defense 1996–1997*, Military Parade, Moscow, 1997

Spasskiy, Nikolai, et al., *Naval Weapons: The XXI Century Encyclopedia of Russia's Arms and Technologies, Vol. 3*, Oruzhie i tekhnologii, Moscow, 2001

INDEX

Page numbers in **bold** refer to illustrations and their captions.

5P851 launcher system 8

Abu Dhabi 20
accuracy 10
active-radar homing system 25
air defenses, modernization 28
Algeria **B2(22–23)**, 22
Almaz 7, 8, 9, 12, 14, 21, 22, **31**
Altair **31**
Antey 36, 44–45
Antey-2500 system **G(42–43)**, **44**, 45, **46**
Armenia 24
army program 8
assessment 46–47
Azerbaijan 24

Batitskiy, P. F 6
Boeing B-52 Stratofortress 5, 6
boosters 9
Bukatov, V. A. 8, **31**
Bulgaria 19
Bunkin, Boris V. **7**, 8, 14

China 4, **18**, 19, 20, 22, 30, **31**
command post vehicles **26**, **30**, 38, 40, 42, **44**
command system **17**, 22
cost 12
Cyprus 20–21
Czechoslovakia 19

dead-zone 9
deployments 13

East Germany 19
effectiveness 47
Egypt **G2(42–43)**, 5, 45
electronic countermeasures 7
electronics technology 16–17
engagement radar 7, 9-10, 11-12, **12**, 13, 17, **17**, 22, **26**, **30**, 31, **31**, **D(33-35)**, 36, 37, **E(38-39)**, 42, **42**, 45-46, **46**
exports 4, 5, 18–21, 30–31, **31**, **G(42–43)**, 45, **46**

Fakel 9–10, 17, **25**, 36
fire control radar system **9**, **13**, 16, 21, **24**, 26, 28, **32**, **33**, 38, 40,
full hemispheric defense 25

GRAU 8
Grushin, Pëtr 4, **7**
guidance approach 9–10
Gulf War, 1991 21

Hungary 19

Iran **B1(22–23)**
Israel 5

Kalashnikov, Mikhail **7**
KB-1 (later Almaz) 4
KBSM 10, 13–14
Kisunko, Grigory V. 32
Kuleshov, Pavel N. 8

launch containers 9, **10**, 11, **D(33–35)**, **36**, 38, **E(38–39)**, 45
Leningrad 14, 16
Lukin, Fëdor V. 7
Lyulev, Lev V. **32**, 33, 36

microelectronics 7
microprocessor technology 17
missiles
  5V55 18
  5V55K 10
  5V55R **10**, 13, 19, **F(40–41)**
  9A83 38
  9M82 **F(40–41)**, 45, 47
  9M82 (Giant) 38, 40, **40**
  9M82M 42, 44
  9M82MD 44
  9M83 **32**, 36–37, **37**, 38, 40, **F(40–41)**, 45, 47
  9M83M 42, 44
  9M96 24–25, **25**, **28**, **F(40–41)**
  9M96D **F(40–41)**
  9M96E **22**
  9M100 25
  40N6 27–28, 45
  48N6 17, 24–25, **E(38–39)**, **F(40–41)**
  48N6D 21
  48N6E 20
  77N6 45, **47**
  77N6-1 45
  ballistic 33
  comparative data 21
  cruise 5–6, 6, **6**, 26
  industry reindustrialization 27
  Krug (SA-4 Ganef) 8, 32, 38
  Patriot 46
  procurement 5
  production 16
  V-500 9–10
  warheads 21, 36
Mokhin, Nikolai V. 14
Moscow Defense Ring 14, 16, 18

NATO 32, 46
naval program 8, 31, **31**
NIEMI 8
Nizhniy Novgorod Industrial Plant 9
Novosibirsk Research Institute for Measurement Devices 9
nuclear warheads 10

OKB-2 (later Fakel) 4
organization 12–13
origins 4–8
Orsha system 12

performance 47
phased-array radar 7, 11–12, 46
Poland 19
Powers, Francis Gary 4
Prizma 32–33
propellant 9
PVO-Strany 4, 5, 6, 7, 8, 12–13, 26

range 10
Raspletin, Aleksandr 4, 7, 8

S-25 Berkut (SA-1 Guild) 4
S-50 Moscow Defense Ring 14, 16
S-75 (SA-2 Guideline) 4–5, 6, 7
S-125 (SA-3 Goa) 5, 6, 7
S-200 Angara (SA-5 Gammon) 5, **5**, 6
S-300 program 8, 9
S-300F Fort/Rif (SA-N-6 Grumble) 31, **31**
S-300P Biryuza (SA-10A Grumble) 8, **8**, 9–13, 46
S-300P transporter-erector-launchers 10–11, **11**, **A(14–15)**
S-300PM Volkhov M-6M (SA-20A Gargoyle) **C2(28–29)**, 16–18, **17**, 26, **E(38–39)**
S-300PMU Export System 18–21, **18**, **19**, **20**
S-300PMU-2 Favorit **20**, 21–22, **22**, **B (22–23)**, 24, **24**
S-300PS Volkhov M6 **11**, 13–14, **A(14–15)**
S-300PT (T: transportiruyemiy; transportable) 11, 11–12
S-300V (SA-12 Giant/Gladiator) 32–33, 36–38, 40, 42, 46–47
  launch **D(33–35)**
  missiles **32**, **D(33–35)**, 36, **38**, 40
  radar system **32**, **33**, 38, 40, 42, **42**, **46**
  role 33
  tracked vehicles 38
  transporter-erector-launchers **36**, **37**, 40
S-300VM (SA-23) 42, 44–45, **44**, **45**
S-350 Vityaz (SA-28) **22**, 24–26, **25**, **26**, **C1(28–29)**,
S-400 Triumf (SA-21A Growler) 26–28, **27**, **28**, 30–31, **30**
S-500 Prometey ATBM 45–46, **47**
S-500U 7–8, 33
semi-mobile launchers 11
South Korea 25
Syria 28, 30

track-via-missile (TVM) terminal homing system 9–10, 10
transporter-erector-launchers 26
  Antey-2500 system 45, **46**
  S-300P 10–11, **11**
  S-300PM **C2(28–29)**, **E(38–39)**
  S-300PMU **19**, **20**
  S-300PS 13–14
  S-300V **36**, **37**, 40
  S-300VM 44
  S-350 **C1(28–29)**, **25**
  S-400 **27**
  S-500 45, 45–46, **47**
Turkey **C2(28–29)**, 30–31

U-2 reconnaissance aircraft 4
United Arab Emirates **A(14–15)**, 20
US Army 20, 21, 25, 32, 46–47
US Department of Defense 30–31
US Strategic Air Command 5, 5–6, 17
USAF 5
Ustinov, Dmitri 8, 14

Venezuela **G1(42–43)**, 45, **46**
Vietnam 21
Vietnam War 4
Vlastelin (Overlord) 45
Voronezh Communications Research Institute 9

Warsaw Pact 18–19

Yefremov, Veniamin P. 8, 14, **32**, 33

OSPREY PUBLISHING
Bloomsbury Publishing Plc
Kemp House, Chawley Park, Cumnor Hill, Oxford OX2 9PH, UK
29 Earlsfort Terrace, Dublin 2, Ireland
1385 Broadway, 5th Floor, New York, NY 10018, USA
E-mail: info@ospreypublishing.com
www.ospreypublishing.com

OSPREY is a trademark of Osprey Publishing Ltd

First published in Great Britain in 2023
This electronic edition published in 2023 by Bloomsbury Publishing Plc

© Osprey Publishing Ltd, 2023

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage or retrieval system, without prior permission in writing from the publishers.

A catalog record for this book is available from the British Library.

ISBN: PB 9781472853769; eBook: 9781472853790;
ePDF 9781472853776; XML: 9781472853783

Index by Alan Rutter

Typeset by PDQ Digital Media Solutions, Bungay, UK

Osprey Publishing supports the Woodland Trust, the UK's leading woodland conservation charity.

To find out more about our authors and books visit www.ospreypublishing.com. Here you will find extracts, author interviews, details of forthcoming events and the option to sign up for our newsletter.

AUTHOR'S NOTE

During the Cold War years, the names and designations of Soviet missiles were unknown to NATO. When new Soviet missiles were spotted by spy satellites, US intelligence agencies assigned a classified, temporary codename based on the location of the sighting. For example, the 9M83 missile was called the Emba-03 since it was spotted at the Emba proving ground. Once the program proceeded to extensive testing, the US Weapon and Space Systems Intelligence Committee (WSSIC: formerly Guided Missile and Astronautics Intelligence Committee (GMAIC) until 1976) gave them an alphanumeric designation such as SA-X-12 (Surface-to-Air Experimental-12) and then SA-12 once it was judged to have entered service. The multinational Air Force Interoperability Council (AFIC: formerly Air Standardization Coordination Committee (ASCC) prior to 2005) gave them a name such as "Gladiator." These are frequently linked together such as SA-12 Gladiator even though they are separate designations by separate institutions. The AFIC/ASCC also assigned codenames to Soviet radars such as Flap Lid, Tomb Stone, etc. In this book, the missiles are identified by their actual Soviet/Russian name, though their WSSIC/AFIC designations are also identified.

Soviet/Russian naming practices can be confusing. Missile programs often began as a research study with a codename such as "Biryuza." Once a program was authorized by the Council of Ministers, it was given a designation such as S-300 (S: *Sistem*: System). The missiles and other major components often had an internal number at the design bureau such as Fakel's V-500 missile. When a missile system was officially accepted for service, the major subcomponents received an industrial index number from GRAU (the Main Missile-Artillery Directorate) such as 5P85, 9M83, etc. In recent years, many systems received a name for marketing purposes such as Favorit, Antey-2500, etc.

Soviet design bureaus and weapons plants often had multiple names for secrecy reasons. In addition, their names changed through time due to government reorganization. For example, the Almaz design bureau was called SB-1 (1947–50); KB-1 (1950–66); MKB Strela (1966–71); TsKB Almaz (1971–88); NPO Almaz (1988-2002), and is now part of the Almaz-Antey corporation. To avoid confusing readers unfamiliar and uninterested in the intricacies of Soviet/Russian defense bureaucracies, this book refers to the major organizations by their best-known identities for simplicity's sake.

ABBREVIATIONS

ABM	Anti-ballistic missile
Almaz	Almaz design bureau, now part of Almaz-Antey
Altair MNIIRE	*Morskoi NII radioelektoroniki*: Naval Radio-electronics Research Experimental Institute in Leningrad/St. Petersburg
Fakel MKB	Otdel No. 4 NII-88, subsequently OKB-2 to 1967, then Industrial design bureau Fakel
GNIIP-10	*Gosudarstvenniy nauchno-issledovatelskiy i ispytatelniy polygon No. 10 MO*: State Research Development and Testing Proving Ground No. 10 of the Ministry of Defense at Sary Shagan, Kazakhstan
GNIIP-11	State Research Development and Testing Proving Ground No. 10 of the Ministry of Defense at Emba
GRAU	*Glavnoe raketno-artilleriskoe upravlenie*; Main Missile-Artillery Directorate
KB	*Konstruktorskoe biuro*: Design bureau; MKB: Industry design bureau; OKB: Experimental design bureau; TsKB: Central design bureau
KBSM	*Konstruktorskoe byuro spetsialnogo mashinostroeniya*: Special Industrial Design Bureau in Leningrad
MNIIAP	*Moskovskiy NII avtomatiki pribostroeniya*: Moscow Research Institute of Automation
NIEMI	TsKB-20, *NII elektromekhanicheskiy* (Electromechanical Research Development Institute) in Sverdlovsk, subsequently NPO Antey, now part of Almaz-Antey
NII	*Nauchno-issledovatelskiy institute*: Research and Development Institute
NIIIP	*NII izmeritelnych priborov*: Scientific Research Institute of Precision Measurement
Novator OKB	OKB-8 of Plant No. 8 im. M. I. Kalinina to 1966; subsequently OKB Novator, now part of Almaz-Antey
NPO	*Nauchno-proizvodstvennoe obyedinenie*: Research Production Association (Russian corporation)
OVZRU	*Orenburgskoe vysshee zenitnoe raketnoe uchilishche*: Orenburg Higher Academy for Air Defense Missiles
PVO-Strany	*Voiska protivovozdushnoy oborony strany*: National Air Defense Force (1954–80) then Voiska PVO, VKO, now part of VKS
PVO-SV	*Voiska protivovozdushnoy oborony Sukhoputnie voiska*: Ground Forces Air Defense
SAM	Surface-to-air missile
SRAM	Short-range attack missile
TBM	Tactical ballistic missiles
TEL	Transporter-erector-launcher
TELAR	Transporter-erector-launcher and radar
TPK	*Transportniy puskovoy konteiner*: transport-launcher container
TVM	Track-via-missile
VKS	*Vozdushno-kosmicheskiye sily*: Aerospace Forces, formed in 2015 by merging the Russian Air Force (VVS) and the Aerospace Defense Forces (VKO)
ZRBr	*Zenitnaya raketnaya brigada*: Air Defense Missile Brigade
ZRP	*Zenitniy raketniy polk*: Air Defense Missile Regiment